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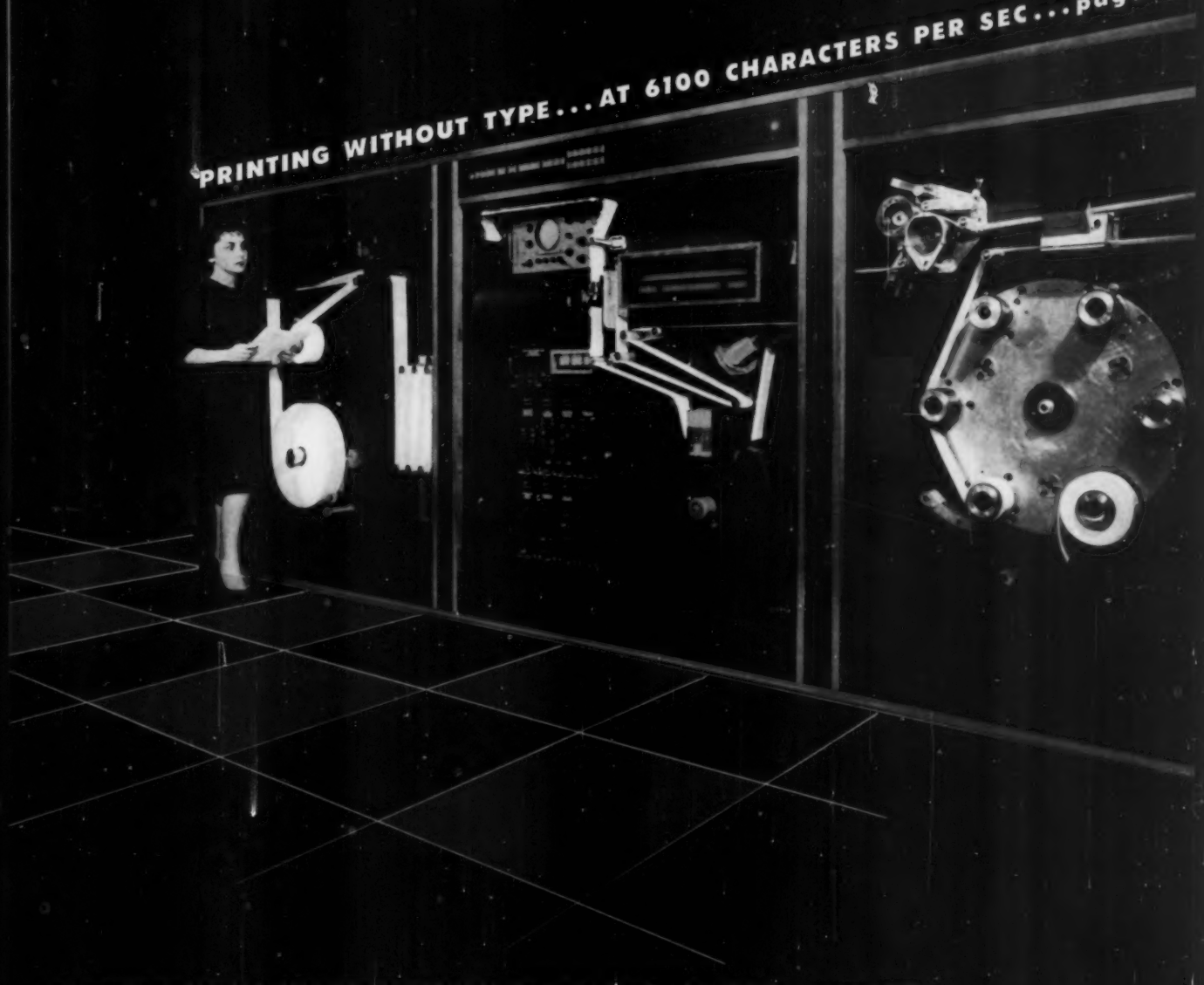

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RESONANCE-FREE DATA FROM YOUR TRANSDUCER... page 72
WHAT BERYLLIUM CAN DO FOR YOU... page 82

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February 20, 1961 Vol. 32, No. 8

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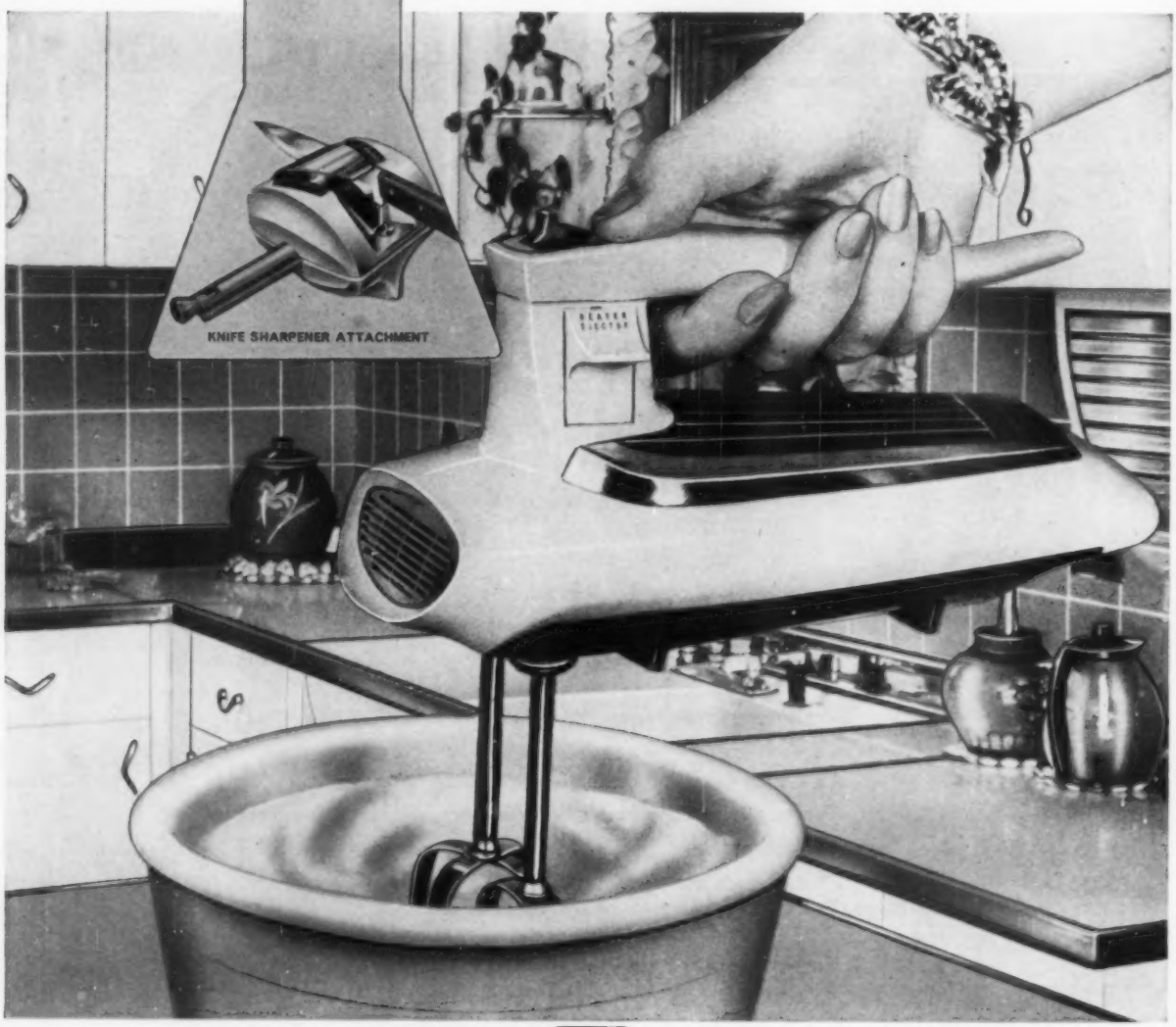

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INTERESTING TO NOTE

Rustproof Wheeling

One of the more modest estimates is that corrosion costs the United States about $6 million per year. This destruction comes in many forms: one of the most troublesome, galvanic corrosion, is the subject of our article on page 87. The steel ships of our day have long suffered the effects of galvanic corrosion upon their hulls. This requires periodic inspection and repair.

When offshore drilling platforms were first sunk in the Gulf of Mexico, engineers found it difficult to coat tierods, complicated joints and numerous crevices with a protective coating. Later designs solved this problem by using tubular members and streamlined joints, with all surfaces readily accessible for coating and repair.

Corrosion was known to the early alchemists although they never understood its chemical properties. The first attempt to "rustproof" a product by means other than painting came in 1906 when Thomas Watts Coslett developed a process for treating bicycle parts as they came off the production line. After five years of experimentation he perfected a chemical method that stopped the parts from corroding. He placed the steel parts in a hot bath containing dilute phosphoric acid. This treatment built up a protective coating on the surface of the steel. Coslett's development of the phosphate-coating technique proved to be one of the most important advances in the history of the metal-processing industry.

A Hill of a Lot of Beryl

Soon after World War II, the materials that had been routed towards the war effort were directed toward peacetime activities. Although, for the most part, this was a most welcome change, it did have some unfortunate consequences. In 1945, a group of boys were playing with a discarded fluorescent light tube. It broke, cutting one youngster on the arm. The cut was not deep but would not heal. In time, ugly sores near the wound started the boy's parents worrying. A doctor diagnosed the infection as beryllium poisoning—caused by a beryllium-phosphor salt used to coat the inside of the glass tube. Such injuries resulting from broken fluorescent light tubes forced manufacturers to use other substances.

Beryllium is news again today, this time constructively. As the article on page 82 points out, its high tensile strength and high elastic modulus challenge titanium and the ultrahigh-strength steels in strength-to-weight ratio. During the war, when beryllium was a strategic metal,

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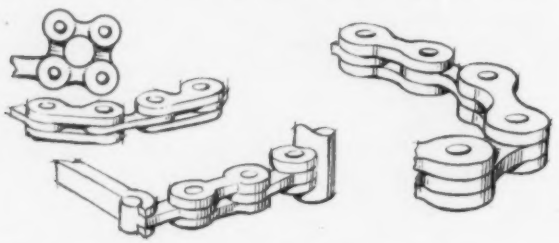
mining engineers from the US Bureau of Mines were sent throughout the country in hopes that certain hard-to-get materials could be located. One of the areas that the mining engineers investigated was Williams Hill near the small town of South Acworth, NH. Attractive beryl crystals had been unearthed there in the early 1800s, but the mineral at that time had little commercial value.

The government engineers detonated several sticks of dynamite and began examining fragments of rock. To their amazement they found that the seemingly insignificant hill was practically solid beryl ore. It was the greatest concentration of beryl ever discovered. In time, the small New Hampshire town became the beryllium capital of the world and Williams Hill was quickly renamed Beryl Mountain.

The da Vinci Driver

One common mechanism used for driving feeders is the simple chain belt. (Another, the four-bar linage, is discussed on page 80). Chains for driving and lifting mechanisms can be traced back to sketches by Leonardo da



Vinci. He made a study of link chains, giving future engineers accurate drawings of a chain type in use today. One design problem that da Vinci faced was friction.

He drew many types of pulley blocks, for example, which he regarded as one of "the wonders of mechanical art." But he had difficulty arriving at a complete distinction between distributing the weight of the load and the diminution of friction between the moving parts. At one time he wrote, "With such an arrangement of roller axles it is indeed true that the weight is distributed among the axles, but if these loads are added up, the resistance will be found to be the same. Just as if we divide a pound into twelve ounces [troy]; when they are added up again they still make a pound."

Leonardo's notebooks are full of drawings showing various mechanical ways to apply energy. He made a study of methods to convert rotary motion into various kinds of reciprocating motion. In an early attempt to utilize irregular geometric shapes in the production and transmission of motion he gave engineers a series of gearing devices whose principles are still being applied. Unfortunately, Leonardo lived too many years ahead of his time, and most of his engineering concepts had to wait until many years after his death before being product-tested.

—Benedict A Leerburger Jr

SIDELIGHT

Several weeks back, we mentioned that the new automatic postoffice in Providence can't distinguish a 4-center from a Christmas seal. This problem will be solved at Winnipeg, Canada's automatic post office with a new $150,000 mail sorter. Photocells mounted on the top and bottom of a conveyer locate the stamp by phosphor pigment lines printed across the stamp. A second ultraviolet photocell station checks stamp values by the number of lines printed on the stamp. Stamps that glow in the dark? What's next?

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Which Instrument-gear Materials Wear Least?**
To help you choose among the increasing number of gear materials, including plastics, here are results of wear tests.

. . . **Feeder Mechanisms—Curvilinear Motions**
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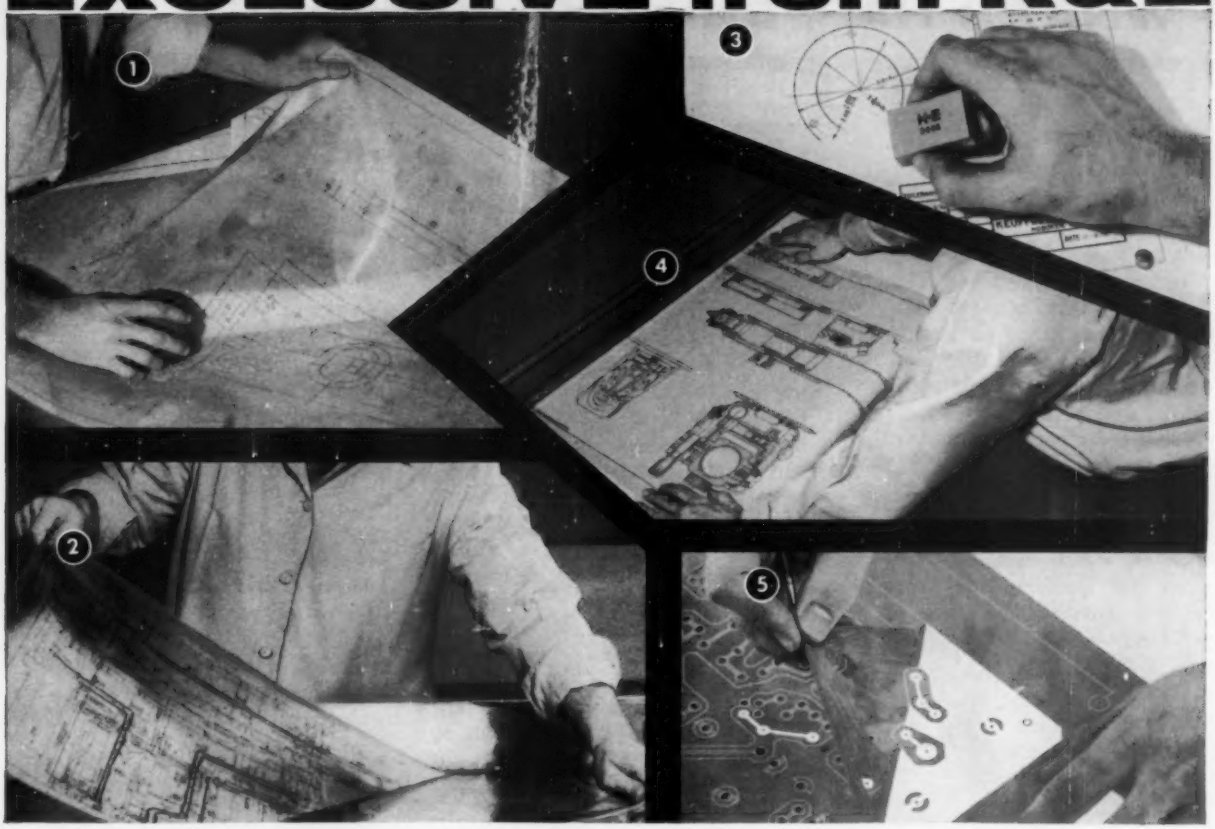

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WHAT'S HAPPENING IN RESEARCH . . .

Soviets design friction tester for plastics

A device for measuring the coefficient of static friction of plastics at loads to 8500 psi has been designed at the USSR Institute of Physical Chemistry. It uses a ring-shape specimen set on a tapered plug, with rod attached, and applies the load by means of a weight, lever, and ball-fulcrum system (see diagram).

The specific pressure is determined by the equation

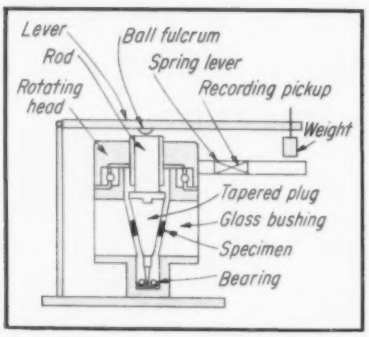
$$p = \frac{N}{2\pi r a \sin \alpha}$$

where N is the load, r and a the radius and length of the specimen, and α is half the taper angle. The coefficient of friction (μ) then becomes:

$$\mu = \frac{M - M_o}{2\pi a r^2 p}$$

or

$$\mu = \frac{(M - M_o) \sin \alpha}{rN}$$



where M represents the torsional moment required to overcome the friction (as measured by the recording pickup and an oscillograph) and M_o is the resistance moment of the bearing and ball fulcrum.

A description of the device, by B. V. Deryagin and coworkers at the USSR Academy of Sciences, appeared in Zavodskaya Laboratoriya.

These ways measure radiant heat

Having defined and characterized the complex of terms and laws surrounding the problem of radiant-heat transfer (*PE*—Jan 2, p 5), Defense Metals Information Center now comes up with a survey of how to measure the key characteristic: emittance. This is defined as *the ratio of the rate of radiant emission from a given sample to that from a blackbody at the same temperature.*

The report describes several types of laboratory setups to measure total and spectral (limited-wavelength) emittance; and then, in an appendix which is almost as long as the body of the report, and at least as useful, describes the various types of radiation detectors: thermocouples, bolometers, and pyroheliometers for total radiation; photoelectric, photographic, and photovoltaic devices for spectral or selective radiation. There is also a brief listing and discussion of temperature-measuring devices: liquid-in-glass, bimetal, and bourdon-tube thermometers for moderate temperatures; thermocouples, resistance thermometers, and pyrometers for higher temperatures. The report (DMIC 78) will be available (as PB 161,228, approx. 20 pages) from OTS, Dept of Commerce, Washington 25, DC about a month from now.

More-flexible coatings for hi-temp conductors

Three ways to improve flexibility of electrical insulating coatings are pointed up by a recent U of Illinois report. The importance of controlling coating composition and thickness is well recognized; but, UI ceramic engineers note, flexibility can also be increased by design of the wire itself and by its heat treatment.

Ceramic coatings on plain copper wire show considerably more flexibility than the same coatings on Inconel-clad wire, they say; and flexibility in both cases can be increased by annealing and oil-quenching the wire after coating.

Adding nickel and iron oxides to the basic ceramic composition also helps increase flexibility of coatings on Inconel-clad copper; while molybdenum oxide seems more effective for silver-clad wire, and copper oxide for stainless-clad.

Electrical properties can be improved, too, by adding vitreous silicon and boron nitride to the coating materials and by sheathing the vitreous coatings with organic materials.

This latest U of Illinois report, third in a continuing series on high-temperature insulating coatings (WADC-TR-58-12, pt III) is being made available through OTS, Dept of Commerce, Washington 25, DC as PB 161954 (75 pages, $2).

(For information on other U of Illinois studies of refractory coatings see *PE*—May 23 '60, p 6, and watch future issues for further reports on developments in this area.)

briefs . . .

Thermal conductivity gage for gas analyzers is calibrated in two ranges (0.35 to 1 and 1 to 7) and reads directly (see drawing) from oxygen (left) to hydrogen (right). It can be equipped with contact-meter relay-

control units and warning-signal systems to indicate when gas mixture exceeds preset levels. Haystings-Raydist makes it, says it is unusually stable and resistant to vibration. Price: about $265.

Photothermal and photomagnetic effects in semiconductors can serve as the basis for improved electronic devices, CBS and Army Signal Research Labs scientists told the American Physical Society's annual meeting.

The *photothermal* (PT) effect results from the "establishment of a temperature distribution in a solid by optically excited diffusing and recombining [electron] carriers and the attendant modification in thermal conductivity.

The *photomagnetothermal* (PMT) effect is the deflection of this thermal distribution by a magnetic field. While the explanation of the effects is complex, they do occur in both silicon and germanium and may be controlled by varying the nature of the incident radiation, and the optical and thermal characteristics of the sample. —ARG

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DEVELOPMENTS TO WATCH...

New chemicals to promote adhesion

New etchants to improve adhesion of fluorocarbon (PTFE) plastics, and new high-purity solvents will be coming from new facilities at Gray Chemical Inc., recently acquired subsidiary of Gorton's of Gloucester (Massachusetts). Gray will also conduct a major research program aimed at uncovering new industrial applications for waste products of its parent company's fish-processing operations. The new etchants and solvents are not, however, fish byproducts, they're sodium-naphthalene-ether complexes and sodium, lithium, and potassium dispersions.

Plastic coatings to protect printed circuits

Dip-coated printed circuit assemblies are to be used in new ground-support equipment being developed in Britain. The reason: such coatings represent the best available compromise between heavy encapsulation and no protection at all. They're thick enough to reduce the danger of abrasion damage to soldered joints and wires, and provide a good deal of protection against humidity and corrosive attack, yet thin enough so they can readily be pierced by a soldering iron when emergency repairs must be made in the field. English Electric Aviation is among the companies doing the development work.

For similar reasons, dip coatings are also receiving a good deal of attention in this country. As papers delivered at recent plastics and electrical engineering meetings indicated all too clearly, the "perfect" coating material has yet to be found; but, right now, epoxy formulations seem to have the inside track, at least for applications in the moderate-temperature range.

Loom without shuttles designed in Britain

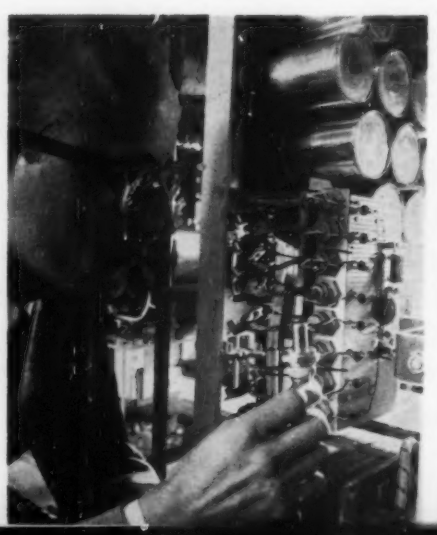
A new weaving system in which the weft (cross-fibers) is inserted without the aid of a shuttle, is being developed at the Manchester College of Science & Tchnology. As described by Prof. J. J. Vincent, the new design differs from the shuttleless "jet" loom by substituting "solid friction applied directly to the weft yarn" for the fluid friction used by the jets.

In the British system, the yarn is inserted between two disks rotating at high speed and is projected forward at a rate (210 ft/sec) which will make it pass through a 1¾-in. ring at a distance as great as 6 ft from the point of projection. Control of disk speed to compensate for the slowing of the leading end of the yarn by air resistance makes it possible to project even relatively fine yarns (50s, cotton count) as much as 5 ft.

The design is to be patented, and commercial production is expected.

New static inverter for high-power jobs

A dc-to-ac inverter with a 50-kva rating —10 times the largest now available— has been built and tested at General Electric. It's a completely static unit, using silicon-controlled rectifiers; GE says it can replace a 60-hp motor-generator set, and will offer a choice of frequencies from 50 to 500 cycles. One aim: to provide a small, lightweight, low-noise unit for use with such new power sources as fuel cells.



STATIC INVERTER designed at GE General Engineering Lab, is less than 1/3 as big as a comparable motor-generator set.

Ceramic-reinforced ceramics make new laminates

Reinforced ceramic compositions that can be molded like plastics at low pressures and temperatures are showing considerable promise for both electrical and structural use, GE's General Engineering Lab reports. These are all-ceramic systems, with aluminum phosphate as binder and fused silicon fibers as reinforcement. The fibers, in the form of yarn or roving, are coated with binder by passing them through a phosphate slurry. Then, parts are produced by conventional filament-winding techniques.

With present materials and fabrication techniques, flexural strengths are on the order of 15,000 psi; but the laminates maintain their strength for considerable periods at temperatures well over 1000 F. They also keep their dielectric properties remarkably well, showing little variation over the entire range.

The GE researchers emphasize that compositions now under test are by no means the best that can be developed.

At the SPI reinforced-plastics meeting, GE engineers noted, for instance, that addition of micro fibers brings the flexural-strength figure close to 20,000 psi; and new binders should double or triple the best performance achieved so far. Pretensioning and controlled microcracking of fibers and binder coatings may also bring considerable improvement. There are problems to be solved here, though, particularly in regard to moisture and chemical attack.

This core material shrinks electronic components

A ferrite with "outstanding hysteresis characteristics" is the key to miniaturization of Nippon Electric Company's new channel filter. And, say Nippon Electric researchers Harou Tomonari and Masanori Koga, it should permit miniaturization of other components as well.

The new composition, which is expected to have a good many applications, replaces standard manganese-zinc ferrites, and permits an over-all reduction of 6 to 1 in core volume. Core-loss coefficient is reduced from 8 to 2, and the hysteresis-loss coefficient from 3500 to 250.

Work is now in progress to improve the stability of the material and permit further miniaturization.

Future power sources: Navy likes thermoelectrics and fuel cells

Thermoelectric generators using series-connected elements, and continuous-feed fuel cells—these are the most promising of the new power sources right now, says J. T. Hayward of the Naval Operations Office (Development).

With materials already available, he says, a variety of useful thermoelectric devices can be built—among them, refrigeration boxes, air conditioners for submarines, and component coolers for missiles. Cost is still high. But, he says, "an intensive effort now mounted on production techniques and fabrication processes will reduce present materials requirement by a factor of five or ten and make Peltier cooling devices economically competitive for Naval use."

Fuel cells, with their potentially high efficiency and relatively low operating cost, are of great interest, though there are still "formidable materials problems." Prototype models of hydrox, sodium amalgam, hydrocarbon, alcohol, and membrane cells are now under construction.

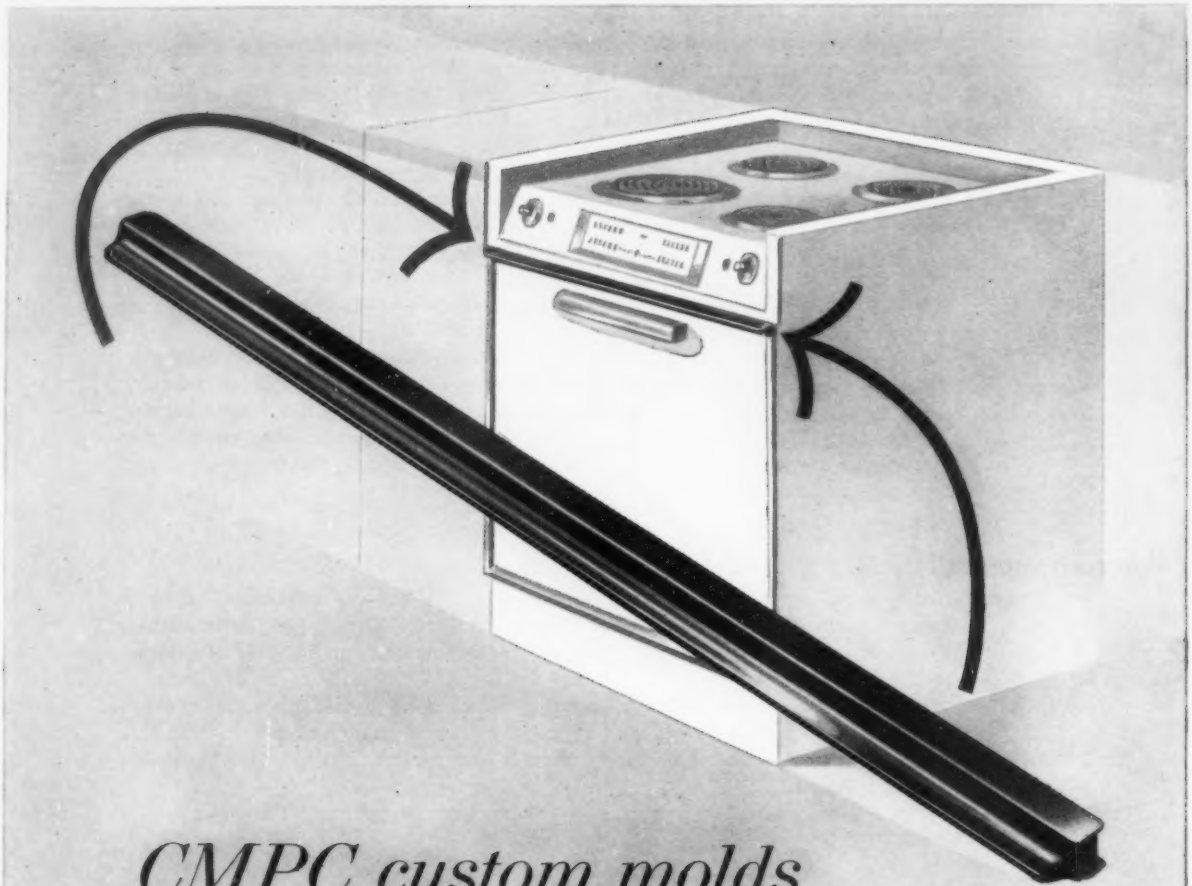
The outlook is not as bright, says Hayward, for solar cells, thermionic devices, and magnetohydrodynamic generators.

Solar cells are the most highly developed energy-conversion units today, Hayward admits. But, he says, the Navy has discontinued its research programs in this area because "other conversion processes appear to offer more growth potential and more widespread applications."

The Navy is, however, still interested in flat-plate solar-energy collectors, using thermoelectric elements sandwiched between sheets of aluminum foil. They're ½ the weight and 1/10 the cost of solar cells; but efficiency is low too, so the collector area must be about 3 times as large.

Thermionic emitters have many potential advantages—light weight, simplicity, adaptability for use with nuclear reactors—but they pose severe materials problems and present-day devices are much too short-lived.

Magnetohydrodynamic devices offer high efficiency. But the system must be large to support inherent losses. In a report to the SAE, Hayward predicted that MHD is more likely to prove out as a propulsion systems than an electric-power source. —ARG



CMPC custom molds phenolic heat deflector for General Electric ranges

Certain models of General Electric's new line of Mark 27 built-in ranges are sporting an attractive CMPC-molded phenolic heat deflector. The 26-inch compression molded deflector, with a top continuous use temperature of 400 degrees F, is used to divert oven heat from the range control panel. By isolating controls from the effects of heat, the CMPC part helps insure longer, trouble-free service—something for which General Electric is famous.

Can the advantages of plastics be applied to your products? When you talk to CMPC, more than forty years experience plus complete compression and injection molding facilities are brought to bear on the problem.

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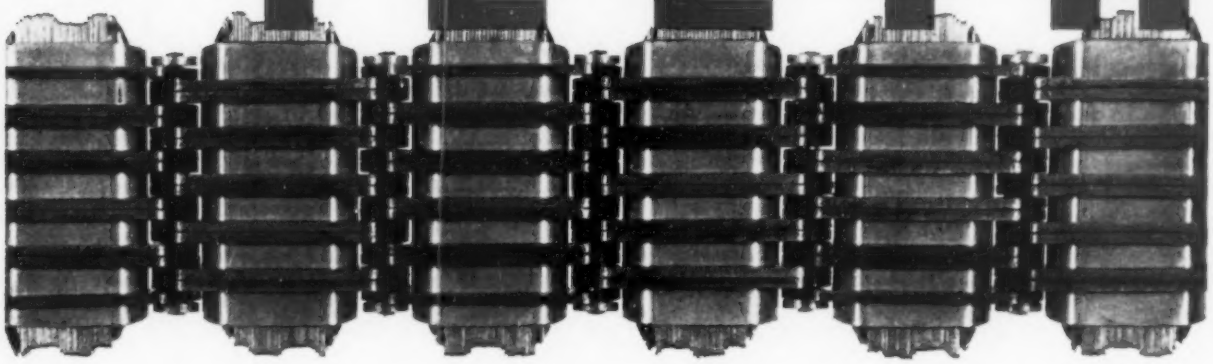
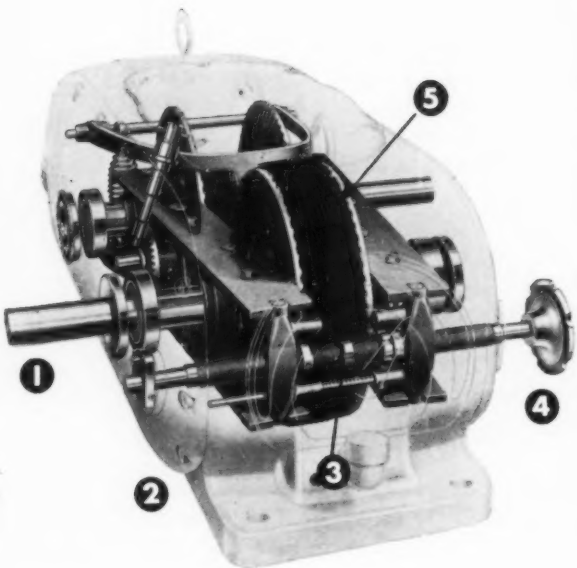
PUT TEETH



IN YOUR SPEED CHANGING JOBS



Get the positive, accurate control that only LINK-BELT's chain-driven P.I.V. can deliver

Yes, you put teeth into your speed changing jobs because Link-Belt P.I.V.—unlike other variable speed drives—utilizes an exclusive metal, self-tooth-forming chain.

Here's how it works! P.I.V. chain consists of a series of overlapping steel links. The links contain packs of slats which are free to move from side to side, singly or collectively, to serve as teeth. The chain meshes with radially grooved wheels, which are cut to a constant depth towards the wheel periphery. Beveled sides of the grooves offer gripping areas . . . provide a positive, nonslip contact at any speed, under all loads.

Makes changing speed simple too! A turn of the control screw simultaneously varies the effective diameters of the conically shaped wheels—closing one set, spreading the other. At the same time, the self-tooth-forming chain automatically adjusts to provide desired ratio between the input and output shafts.

BOOK 2274—Your Link-Belt office has Book 2274 on P.I.V. drives ½ to 25 hp. Refer to the yellow pages of your local phone directory under Power Transmission Equipment.

(1) You can get minute speed changes and maintain them accurately while operating under full load.

(2) All-metal, totally enclosed—unaffected by atmospheric conditions. All vital operating parts splash-lubricated from a common housing reservoir.

(3) Easy-view speed indicator facilitates speed selection and adjustments to meet all requirements.

(4) An infinite number of positive, stepless speed adjustments may be made with manual, electric, pneumatic or hydraulic controls.

(5) Self-tooth-forming chain is made from a series of overlapping steel links. Links contain packs of hardened steel laminations or slats (shown above). Slats grip toothed wheels positively without slippage —give the speed you need at any setting.

15242

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

LINK-BELT

P.I.V. VARIABLE SPEED DRIVE

FROM WASHINGTON . . .

New Plastics Institute to emphasize research

Assured of industry-wide support by returns from a questionnaire survey, the Plastics Institute Committee decided this week to proceed with formal incorporation of the Plastics Institute of America. **The new organization will be primarily concerned with solving technical problems in the industry. It is expected to give considerable attention to basic and fundamental research into the properties and characteristics of plastic materials** as well as to plastics engineering. The results of this research will be made available to producers, processers and consumers. The Institute will also encourage graduate education of qualified engineers and chemists by affiliating with one of the country's leading educational institutions.

Rover nuclear engine nears production phase

A nuclear-powered rocket engine for space use is getting closer. The Atomic Energy Commission and the National Aeronautics and Space Administration, working jointly, have called for company proposals for building the nuclear-powered Rover engine.

The bids, due on April 3, will be on a package program that includes: rendering assistance to Los Alamos Scientific Laboratory in the conduct of the Kiwi-B test program; preliminary design of a flight engine; configuration of an engine development program; and performance of certain R & D tasks on nonnuclear components.

Total cost of the Rover program is not known, but some $37.4 million is earmarked for it in fiscal 1962. Completion of the project will take five years or more. At present the Rover engine is seen as a second stage for the Centaur and Saturn engines now under development.

Longer range Polaris runs into trouble

The Navy is having problems with its A-2 model of the Polaris missile. After three partly successful test shots, the fourth exploded on the launch pad recently. So far, Navy won't say what went wrong.

The A-2 model of Polaris is designed to extend the missile's range from the present 1200 nautical miles to 1500 mi. It is slated for use by early 1962.

Within the next two to three years, Navy plans to extend the missile's range to 2500 miles with its A-3 version of Polaris.

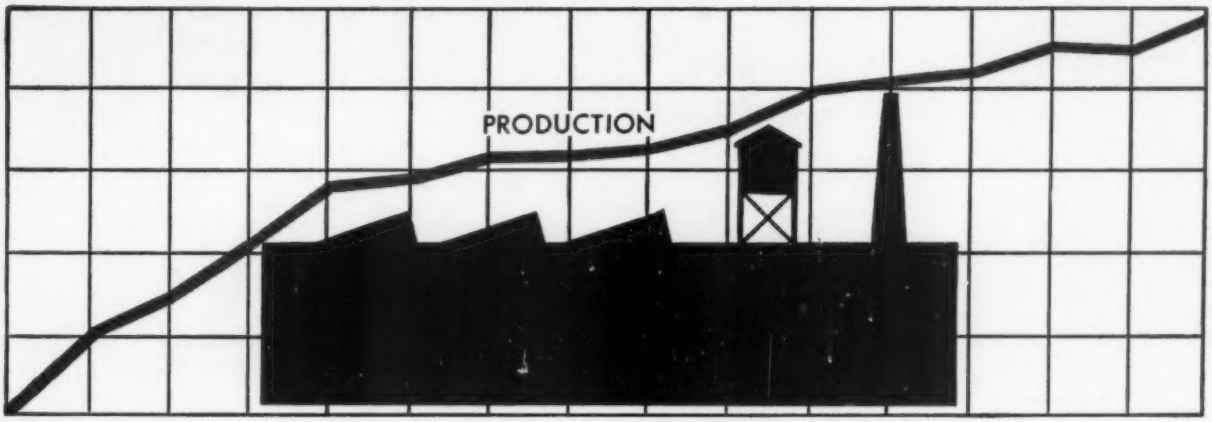
Modification of the first five Polaris-armed submarines will be necessary to carry the longer range missiles. The reason is that about 30 in. has been added to the 28-ft length of the A-1 version for extra range. No change, however, has been made in the 54-in. dia of the missile.

AEC continues its internship program

The Atomic Energy Commission is again offering internships to outstanding college or law school graduates as part of a continuing program to support its administrative functions with young, trained executive talent.

The internships are in four categories: nuclear engineering, management, legal, and patent attorneys. Trainees in all four categories are given a standard orientation in Washington or an outlying AEC installation to acquaint them with the agency's staff, policies, functions and place in government. Then they are given special training depending upon their specialty.

Since its inception in 1954, internships have been granted to 119 young men and women, 71% of whom are still with the AEC. Applications for engineering and management internships should be sent to Robert Palmer, Director, Organization and Personnel, US Atomic Energy Commission, New York. Other applications go to the AEC in Washington.



How to expand without added expenditure

Right away let's make this point clear: you won't find any magic formula here for expanding your plant physically at no cost. What you *will* find are facts about a material that can definitely help expand your plant's productivity . . . and your product's salability.

That material is Masland Duran Clad, the new semi-rigid vinyl for laminating to metal sheets or coils according to your specifications . . . the built-in finish that obsoletes dipping, spraying, brushing, coating and similar finishing methods . . . the vinyl-to-metal laminate that can even do away with the need for having a finishing department.

Think what this can mean in terms of expanded productivity. Space now devoted to finishing operations can be used to expand your production area. Money currently spent in equipment, maintenance and finishing supplies can be channeled to more productive use. Costs of rejects, and the insurance costs of handling explosive materials can be eliminated, too, since Clad enables you to work with *prefinished* parts.

Consider, too, what Clad can mean in greater sales potential for your product. This durable, decorative vinyl can be produced in easy-to-clean colors . . . and in plain, textured or embossed designs. And here's the beauty of Clad from a production standpoint: It can be cut, crimped, drilled and even deep-drawn, without affecting color or design . . . without distorting the material itself . . . and without the need for any special processing equipment or methods.

Truly, Masland Duran Clad merits your most serious consideration right now . . . for, make no mistake about this: *vinyl-to-metal laminates are here to stay and grow.* With production soaring from one million square feet to 18 million in just three years . . . and from 125 to 165 million square feet estimated for 1961 . . . they are obviously lowering finishing costs and increasing design flexibility in a big way.

To safeguard and improve *your* competitive position, you will find it well worthwhile to mail this coupon for more information on Masland Duran Clad . . . and the laminators serving your area.

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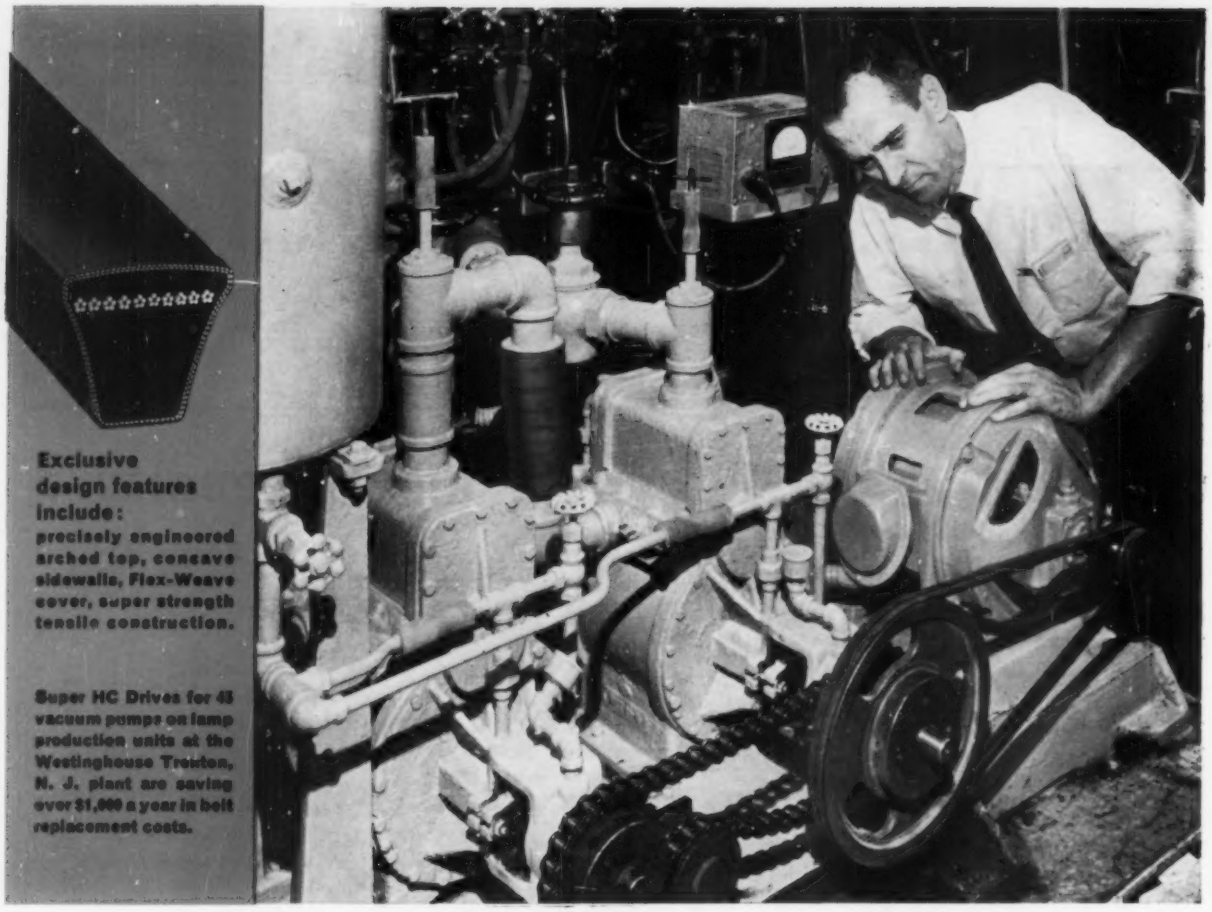


Exclusive design features include: precisely engineered arched top, concave sidewalls, Flex-Weave cover, super strength tensile construction.

Super HC Drives for 45 vacuum pumps on lamp production units at the Westinghouse Trenton, N. J. plant are saving over $1,000 a year in belt replacement costs.

Westinghouse converts drives on 45 machines to new Gates Super HC High Capacity V-Belts

When drive space is limited, a driver sheave too small in diameter is sometimes used—though not recommended. Constant flexing over a small sheave is severe punishment for V-belts. Because of this, conventional V-belts lasted 4 months or less on the vacuum pumps on lamp production units at the Westinghouse Lamp Division plant in Trenton, N.J.

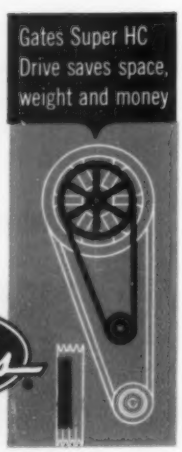
Now, with space-saving Gates Super HC High Capacity V-Belt Drives on all 45 machines, all belts are still running strong after more than 1½ years . . . a saving of over $1,000 in belt replacement costs plus even greater savings through reduced down-time.

The Gates Super High Capacity V-Belt is a new concept in V-belt design.

It is industry's first and most advanced high capacity V-belt. Because of exclusive design features, Gates Super High Capacity V-Belts transmit up to 3 times more horsepower than conventional V-belts in the same space. Or the same power can be handled with fewer belts and smaller sheaves in less space.

As a result, Gates Super HC Drives save up to 50% in drive space . . . cut your drive costs as much as 20% . . . reduce drive weight 20% and more . . . and make possible further savings in material costs.

Your local Gates Field Engineer is an experienced, fully-qualified drive design expert. Contact him for Super HC design information and for design help.



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Gates Super HC V-Belt Drives

THE ENGINEERING WEEK

Red China Industry Nears Technical Independence from USSR

NEW YORK—Speculation over how far Communist China has gone toward developing her sciences and industries is beginning to give way to hard fact. The facts, as reported to the American Association for the Advancement of Science by E. K. Nieh, senior mechanical engineer with Ebasco Services Inc, point to a rate of industrialization that is sufficient now, or will be soon, to free the country from Soviet aid in many crucial areas.

Nieh based his information on translation of Chinese documents which have been collected by the MIT library. His researches show that the Chinese People's Republic placed especially strong emphasis on building up the country's basic industries during the 5-year plan ending 1957. Industrial efforts included plants for processing iron, steel and other metals, machine tools, power-generating facilities, and facilities for manufacturing agricultural and transportation equipment.

The plants for producing equipment to exploit China's rich mineral resources are concentrated at five centers: Fulaertzi, Taiyuan, Lanchow, Loyang, Fushun. (see map).

• Major products of the Fulaertzi plant include bloomings, large rolling mills for rails, and equipment for blast and open-hearth furnace shops.

• The heavy-machine plant at Taiyuan specializes in medium and small rolling mills, metallurgical ladles, forge-press equipment, and equipment for coking batteries.

• Lanchow is the center of the oil equipment industry. A plant started there in 1956 presumably went into production in 1959.

• The Loyang plant is now turning out various types of heavy mining equipment such as hoists for coal mines, and percussive and other boring machines. This city is also location of a tractor and ball-bearing plant.

• The Fushun machine-building plant has been considerably expanded to produce perforators, pneumatic drills and other pneumatic equipment, excavators and hoisting machines.

Tractor production is being steadily increased in Red China, according to information obtained by Nieh. The plant at Loyang, which went into production in 1958, has annual rated capacity of fifteen thousand 54-hp

tractors. A converted diesel plant in Changchung, scheduled for operation in early 1959, is believed to have annual capacity of 10,000 tractors with 24- and 30-hp engines. A second converted diesel plant—this one in Nanchang—is scheduled for 50,000 farm vehicles a year. Other types of agricultural equipment are scheduled for the Peking agricultural machine-building plant, where tractor-drawn and self-propelled combines and other implements are being manufactured.

Mainland China has mastered production of many types of modern lathes, milling and drilling machines, reports Nieh. New and expanded machine-tool, instrument and ball-bearing plants are going into operation in Shengyang, Harbin, Ukhan, Chansha, Chuntsin. Machine-tool building plant No. 3 in Peking, one of China's largest of this type, specializes in universal and plane milling machines. A reconstructed plant in Chan-sha is scheduled for triple capacity when complete.

PRECISION MACHINES WERE SCARCE

For some time, the Communists apparently suffered from a bottleneck in facilities for manufacturing heavy precision machines. But since 1958, reports state, a plant in Ukhan has been making boring and turning lathes, horizontal drilling machines, thread-milling and planing machines. These are said to range in size from 20 to 760 tons.

A ball-bearing plant at Loyang went into partial production in 1957 and now is presumably in full production. The first production run included about 2200 truck bearings. Plant blueprints called for capacity sufficient to keep 100,000 tractors equipped with ball bearings.

Modern industry's increasing need for instruments is provided for in the reported Chinese plan. A plant in Sian is scheduled to produce 140 different types of automatic control regulators. A second plant in Chansha will turn out electrical instruments for tractors and trucks.

Cutting and measuring instruments for machine-building plants have also posed problems. These were solved in large part when the plant at Harbin went into operation in 1956. Its output is said to be sufficient to supply instruments needed by 40 large machine-building plants. A second plant, in Chengtu, with 30% greater capacity than the Harbin facility, was started in mid-1956. And the cutting instrument plant at Shanghai is reported to maintain annual production rate of 440 tons of precision cutting instruments.

Communist China is also putting considerable emphasis on providing transportation equipment, Nieh told the AAAS. A shipyard at Dal'niy reportedly has capacity to construct ships powered by 13,000-hp engines with displacement ranging up to 22,000 tons. A locomotive and railroad-car producing plant is located in the same town. The new 1-5-1 locomotive for freight trains is claimed to have high operational qualities. About 446 locomotives, 27,600 freight cars, 1700 passenger cars, 3000 railroad tank cars and 2200 dump cars were built in China during the 5-year plan ending 1957.

It is perhaps of utmost significance that China has apparently mastered these various industrial techniques to the point where she is no longer dependent upon Soviet aid and can even promise assistance to lesser developed countries in Asia.

The Soviets in the past have offered considerable technical assistance. They built China's first automobile plant, both the instrument and boiler plant at Harbin, and the Shengyang machine-tool plant No. 1.

Likewise, most equipment for the first two blast furnaces at the Anshan metallurgical combine was imported from the USSR. But subsequent blast furnaces have been almost entirely fitted with Chinese-made equipment. The blowers and a few minor components were imported. The second open-hearth furnace at Anshan was almost entirely a product of native electrical and machine-building enterprises.

Most machine tools are built on Soviet blueprints or those of other Socialist countries. Production has now risen to the point where new metalworking factories are almost basically equipped with Chinese-made tools. Tractor plants are a case in point.

EXPORTING SOME EQUIPMENT

Growing self-sufficience of her industries means that Communist China has been able to cut machinery imports and can now export some equipment. Exports include not only consumer items like typewriters, bicycles and sewing machines, but equipment for light industry as well, including textile mills and sugar refineries. China has completely outfitted a textile mill in both Burma and the United Arab Republic. An agreement with the nearby puppet, the Mongolian People's Republic, calls for construction of a worsted mill, a paper mill, a plywood plant, a brick-making plant and a facility for manufacturing prefabricated wooden houses. ■

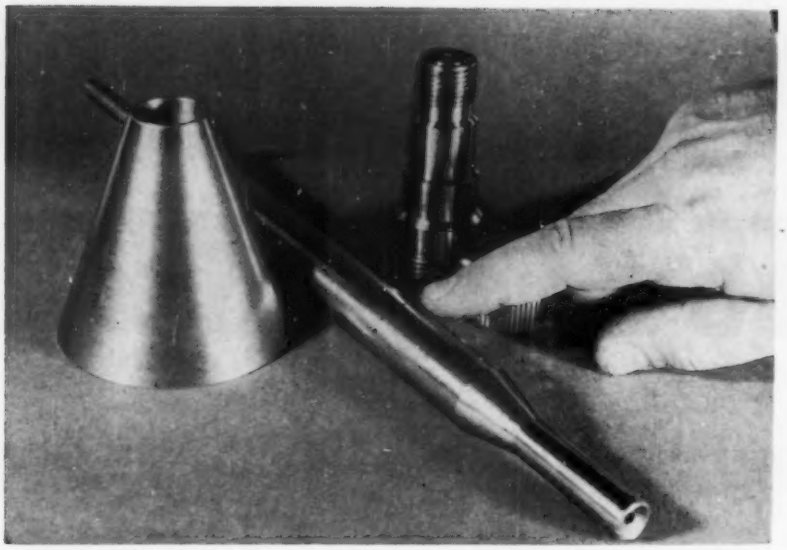
Soviet Scientists Deplore Industry's Lack of Interest

Moscow—At the annual meeting of the Academy of Sciences, Soviet scientists agreed that they are making unprecedented progress, particularly in space and automation research. But they conceded that a major problem remains—how to speed translations of these scientific advances into production-line technology.

Commenting on present sluggish adaptation of science, A. N. Nesmeyanov, president of the Academy of Sciences, told the group that despite major efforts and some progress, cooperation between science and industry is still unsatisfactory. The annual plan, which lists research achievements recommended for industrial use, contains mostly items of secondary importance. The best contributions have been made outside the plan, reflecting poor planning and organization, he charged.

The Soviet scientists also appealed for more equipment in research institutes to bring them abreast of the demands of present-day experimental needs. And he called for a sharp increase in the number of scientists—all with better training on the interrelation of various scientific branches.

Y. K. Fyodorov, "chief learned secretary," listed areas that should be emphasized in Soviet research. These included space, thermonuclear power, artificial photosynthesis, synthetic foodstuffs, direct conversion of chemical energy into mechanical energy and research into the depths of the earth. ■



MISSILE-PROBE COMPONENTS withstand high frictional heat better if they are chromallized. Untreated molybdenum oxidizes into white smoke at about 1400 F, but alloy-treated molybdenum has withstood 3850 F for 45 sec.

Chromallizing Protects Missile Probes from High-temperature Damage

DOVER, NJ—Problems of oxidation and metal erosion of molybdenum-alloy probes for guided missiles appear lessened with development of an alloy diffusion process, according to Arnold Sprinz, a mechanical engineer of Picatinny Arsenal. The process diffuses a complex of chromium and other metals into the surface of the probe.

The alloy, called W-2 surface alloy and developed by Chromalloy Corp, not only protects the probe against high temperatures induced by air friction (3850 F for 45 sec) but also reduces the heat-transfer rate to hold down equilibrium temperatures throughout the probe.

These probes have a two-fold function: they furnish velocity pressure, which is obtained through the probe's hollow core, to prevent maneuvers in the guidance system that would cause excessive g loads; and they sense static pressure which initiates system fuzing.

DESIGNING THE PROBE PROFILE

Because the probe's configuration directly affects the amount of airstream friction heat, which, in turn, affects flight accuracy, considerable care was necessary in its design. After extensive wind-tunnel testing, Picatinny engineers decided on a probe (see photo above) measuring 14.029 in. long with a $\frac{7}{8}$-in. OD, the main body tapering near the tip to 0.500 in. OD. A hole with an ID of 0.127 in. runs the full length of the probe's centerline and serves to channel total pressure which is converted to velocity pressure. About 4 in. back from the hollow tip are 15 tiny holes spaced evenly around the probe's circumference. They bleed static pressure into a second channel leading to the base of the probe. The concentric groove which connects the base of the probe to the static-pressure inlet holes is trepanned, after which the center hole is spark-machined, concentric with the trepanned hole within 0.001 in.

Before Chromalloy's W-2 was adopted, Picatinny engineers tried a number of other combinations. An ablative coating (which slowly transforms from a solid to a gas as heat is absorbed) was ruled out because it would alter the probe's shape, and any change in the probe's external configuration would cause erroneous readings.

But while molybdenum gives high strength at elevated temperatures, there was still the problem of protecting the metal against oxidation. Unprotected molybdenum probes begin to oxidize when exposed to airstream temperatures of 1400 F and above. Oxidation barriers tested included: ceramic-coated molybdenum, a heat-resistant refractory alloy, molybdenum with aluminum-silicon oxide, ceramic-coated stainless steel and molybdenum with W-2 chromallizing. The ceramic coatings, having a thermal coefficient of expansion approximately three times that of molybdenum, actually pulled away from the probe. Only chromallized specimens met the stringent tests conducted at the ceramic jet-test facilities at Langley AFB, Va. In fact, treated molybdenum samples have maintained their strength for extended periods.

One company has heated a test panel with a gas-air torch to 1800 F in 30 sec, and held it at this temperature for 15 sec. The panel was then cooled to room temperature in 45 sec. This test was repeated 2000 times without panel failure. In addition, tubing protected by the W-2 surface alloy has been exposed to 2500 F steam for 6 hr without harm.

According to Chromalloy, active elements combine with the base metal during diffusion to form a range of new alloys. At the surface, the alloy is rich in the metals introduced, but decreases in alloy content until the original base metal is reached. Metallographic examination usually reveals two or three distinct layers, with boundaries at certain fixed percentages of alloying elements. Thickness of the surface alloy can be varied by manipulating processing conditions. Chromallized thickness of 1 to 3 mil generally gives optimum results.

Because the resistance to oxidation is enhanced by the diffusion alloy, molybdenum is now expected to find application in jet-engine buckets, rocket-motor components, nuclear-reactor rods and in any area where excessively high heat creates materials-selection difficulties. ■

An Answer? Hire Jobless to Care for Jobless

BONN—While West Germany basks in the warmth of full (virtually) employment, one dark cloud hovers o'er her economic scene. Floating in the form of a statistic, this cloud is giving economic prognosticators pause, to wit:

Some 34,000 government officials

continued on page 20

GOODYEAR

NEWS! ONLY V-BELTS BY GOODYEAR

to give you sets matched in length to pull together

What's more, Green Seal V-Belts give you—

True dimensional stability for the life of the belt—built in through the use of shrink- and stretch-resistant 3-T Process Cord or airplane-type steel cable.

Mildew-inhibited construction for protection in damp operating conditions.

Widest selection from the most complete V-belt line anywhere.

Ready availability from distributor stocks in every part of the country.

Technical assistance whenever it's needed from a qualified expert, the G.T.M.—Goodyear Technical Man.

For the best buy in V-belts call your Goodyear Distributor. Or write Goodyear, Industrial Products Division, Akron 16, Ohio.

Lots of good things come from GOODYEAR

GREEN SEAL ARE CODED TO 1/32"...

perfectly for longer, more trouble-free service

LENGTH-CODING GREEN SEAL V-BELTS TO 1/32"—NOT JUST 1/10", LIKE MOST BELTS—takes this ultra-precision machine. Only Goodyear has this type equipment, which is set by means of fine tolerance steel templates to insure accuracy. Machine readings are in the actual code numbers used to eliminate errors.

Green Seal—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

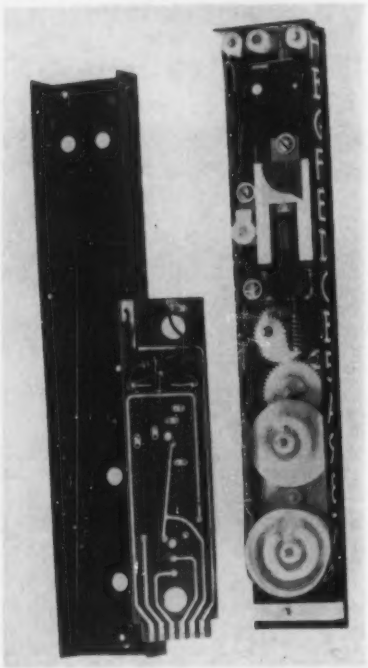
YEAR INDUSTRIAL PRODUCTS

Continued from page 17

(full-time employes) have been hired to look after the welfare of the nation's 272,000 unemployed.

The increasing costs of looking after a decreasing number of unemployed is a problem many another nation would welcome, but the Germans consider it a thorn in their side. In a recent referendum, the Federation of German Taxpayers pointed out that the Labor Dept is costing the average German taxpayer about $450 million annually. ■

Plastic's Uniform Properties Answer Fatigue Problem



Nine separate parts (gears, cams, rollers) made of DuPont Delrin are used by the General Railway Signal Co in its data indicator. Banks of the indicators are at work in such operations as airport traffic control, sorting and filing up-to-the-minute information on flight factors, field conditions and weather. The indicators must operate without lubrication in high ambient temperatures with minimum maintenance. Failures occurred in the original plastic materials selected because of uncontrollable dimensional tolerance and fatigue in gear teeth and drive pins. A switch to the acetal resin eliminated these failures and gave more consistent and reliable braking in critical parts of the assembly because of the uniform fractional properties of Delrin. It was introduced a year ago at 95¢ a lb; DuPont announces that, effective March 7, the price will drop from 80¢ to 65¢ a lb.

Industry Splits Over Specs Needed for High-pressure Teflon

NEW YORK—The Society of Automotive Engineers G-3D subcommittee is trying to set military specifications for high-pressure high-temperature Teflon hose assemblies for aircraft and missile fluid systems. But unlike earlier success with medium-pressure hose, their work on specs for the high-pressure product (3000 psi) shows signs of developing into a hose-industry rhubarb. The medium-pressure specs (1500 psi) resulted in MIL-H-25579 and issuance of Qualified Products List. They are basis for most aircraft- and missile-company hose procurement.

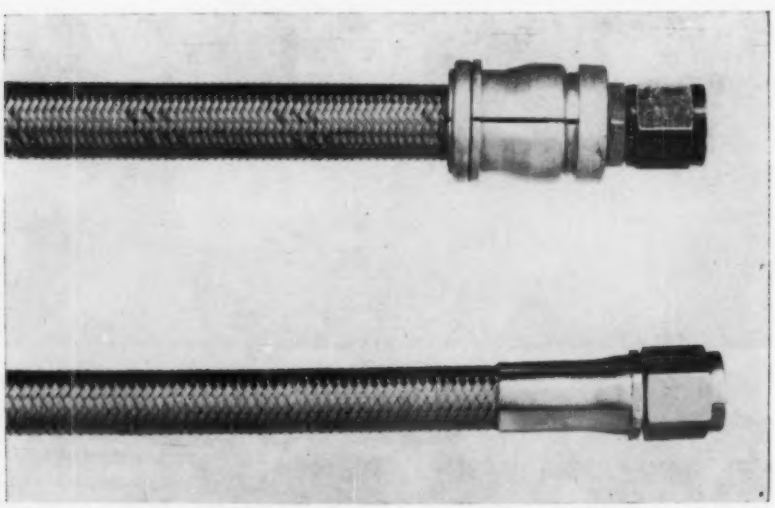
As a prelude for setting high-pressure-hose military specifications, SAE prepared an aircraft-recommended practice (ARP 604) for high-pressure Teflon assemblies. These recommendations called for hose tough enough to withstand operating pressure up to 3000 psi, temperature up to 400 F and hydraulic surge of 100,000 cycles of pressure impulses, with pressure increasing to 4500 psi in 1/35 sec.

Trouble now is that manufacturers have taken different approaches to design of high-pressure hose. Some conservatives have come up with a product that exceeds ARP requirements in certain areas. Their hose has consistently passed 250,000 pressure impulses. And minimum burst pressures, in some sizes, exceed spec values. But this improved performance has been achieved at expense of increased weight, size and cost. Some hoses for 3000-psi service have one or more layers of carbon spiral wrap over the Teflon inner core and at least one layer of stainless steel braid as an outside layer. Fittings tend to be large, bulky and heavy.

On the other hand, competing companies have designed an assembly to meet the ARP 604 requirements with minimum space, weight and cost penalties. They've retained 100,000-cycle-impulse pressure requirements, but have reduced minimum burst-pressure values to ratios set for medium-pressure specs: proof pressure is set at two times' operating pressure; minimum burst, four times' operating pressure. In original drafts of ARP 604, room-temperature burst did not strictly follow this rule. In some sizes, minimum burst was set at four times' operating pressure.

As a result of these divergent design approaches, two entirely different products have emerged. One resembles medium-pressure hose in size, weight and flexibility; the other is heavier, more bulky and requires more force to bend.

One solution offered the SAE specs committee is to write two different specifications. One would be called "Lightweight Hose Assemblies, Aircraft and Missile General Service,



Teflon rivals vie for military OK: hose at top, now offered by some companies, is designed for higher burst pressures and hydraulic surge conditions than hose at bottom, and exceeds present SAE specs. Its opponents call it unnecessarily heavy, bulky and overdesigned for present missile and aircraft requirements.

High Temperature (450 F), High Pressure (3000 psi)" and would be renumbered ARP 619. It would call for slightly higher temperatures than ARP 604, add maximum weight limits, reduce fitting envelope values, and modify minimum burst-pressure requirements to conform with 1:2:4 ratios adopted for medium-pressure hose assemblies.

The other specs would retain the ARP 604 designation but would prescribe somewhat higher performance standards for additional safety. Hydraulic impulse requirements would be increased from 100,000 cycles to 250,000 cycles for ¼ to ½-in.-dia hose. In larger sizes, 100,000 cycles or less would be specified because it is doubtful that existing designs can exceed these values. Minimum burst pressure would be retained at original values, and allowable maximum values for fitting diameters would be increased to accommodate products which are available.

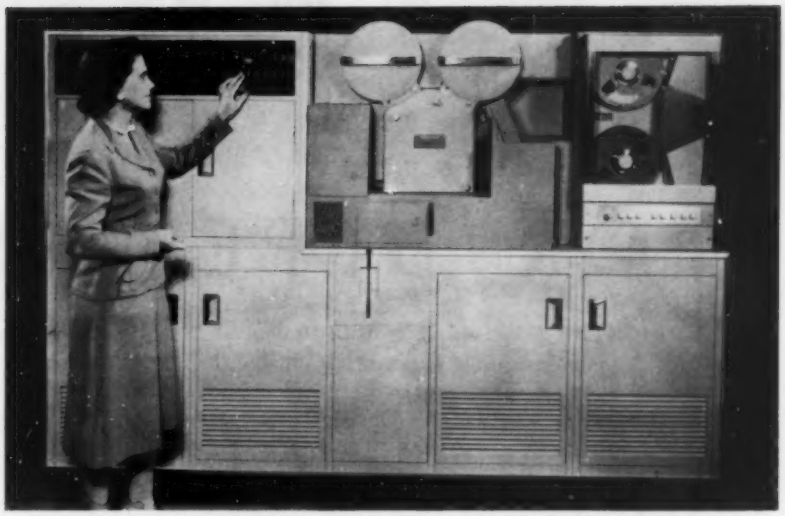
Drafts of the two specs have been completed: draft 3 of ARP 619 was published on November 1, 1960; the original draft of ARP 604 was issued on December 19, 1959. The revised ARP 604 will be presented at the next committee meeting.

DRAFTS STIR CONTROVERSY

These drafts are expected to become a storm center. A poll of members shows disagreement over need for the two specifications or the value of one or the other of them. Advocates of revised ARP 604 point to added reliability and safety; dissenters to the narrow range of sizes actually effected. Dissenters also note that 100,000 impulse cycles is still the standard for other components of hydraulic systems and is adequate in latest aircraft and missiles. Furthermore, if ARP 619 should be eliminated, they say, missile and rocket engineers would have to purchase over-designed hose—with resulting penalty in weight, space and cost.

The controversy will not be resolved until the SAE subcommittee meets later this year. Meanwhile the committee is soliciting opinion of committee members and engineers who use the hose in aircraft and missile industries. ■

Converts Tape to Microfilm at 20,000 Characters Per Second



This computer printout system can reproduce a complete printed page containing as many as 8000 characters in about ⅓ second on one 16mm microfilm frame. Called DACOM (Datascope Computer Output Microfilm), the printer takes digital input and makes prints of "graphic-arts quality" at up to 20,000 characters per second, according to Recordak, a subsidiary of Eastman Kodak, which developed the system. The microfilm can be stored as-is, thus easing the burden of filing, or turned into hard copy by another machine. Data can be printed to conform to any format (such as a statement, bill or accounting forms). DACOM can plot graphs and also fill in printed information at 15,000 characters per second; no overlays or descriptive labels are needed.

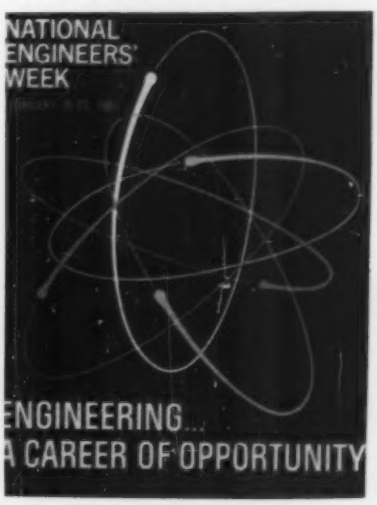
Britain, France Press for European Space Club

STRASBOURG—A third space power came closer to reality when Britain and France proposed a 5- or 6-year cooperative rocket development and launching program to delegates from 10 other European countries here. The joint sponsors suggested Britain's Blue Streak for the first stage, an improved French Veronique for second stage, and a European-designed third stage (*PE—Oct* 17 '60, *p* 15).

The tab for such a venture, they estimate, would run about $200 million, which could be split among members, depending upon their national income. Such a sum is expected to be enough for 8 firings, with the last three capable of putting satellites into orbit.

Even if the space club comes into being, launchings are some time away. At least a year will be needed to get the Blue Streak's first stage ready, and the French propose to step up thrust of the Veronique from 8,800 to 55,000 lb—a job that will take a couple of years.

The proposed European space unit would complement work of the European Space Research Organization set up at Geneva last year to develop satellite instrumentation. Eight countries have approved the research program (Britain, France, Belgium, the Netherlands, Norway, Spain, Sweden and Switzerland), and all sent representatives to the Strasbourg conference. Also, Austria, Denmark, West Germany, Italy sent representatives and Canada, Greece, Turkey sent observers. ■



GRAPHITAR®

(CARBON-GRAPHITE)

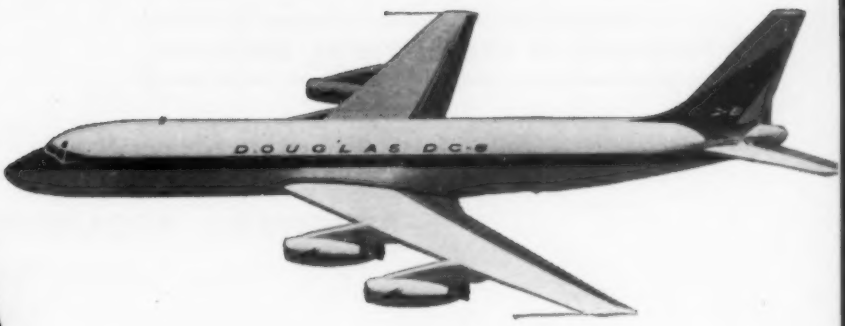
FOR DEPENDABILITY

GRAPHITAR'S own character makes it dependable. A non-metallic engineering material, formed from carbon and graphite powders and a special binder, compacted under high pressures and furnaced at temperatures up to 4,500°F., GRAPHITAR possesses inherent characteristics that give finished parts exceptional dependability. GRAPHITAR'S natural heat resistance, for example, gives bearings, seals, vanes and rings exceptional dependability whenever dependability is one of the prime requisites.

There are other characteristics every bit as important to GRAPHITAR'S dependability. They include chemical and magnetic inertness, mechanical strength and adaptability to self-lubrication. Besides these natural characteristics, GRAPHITAR engineers can control porosity, strength and hardness to match GRAPHITAR'S physical properties to each individual application. It's little wonder that GRAPHITAR has become one of the design engineer's most versatile and useful materials.

In this laboratory test stand, oxidation-resistant GRAPHITAR parts are being checked under simulated operating conditions. Similar tests have proven that, when GRAPHITAR parts are exposed in oxidizing atmospheres at 1,200°F., they show only a weight loss of less than six percent after 200 hours.

In the Engineering Department of The United States Graphite Company, micro-photo studies are indispensable in the study of internal part structure. The Metallograph is just one of dozens of modern technological aids employed in both the quality control of production GRAPHITAR parts and in the research and development of new products. GRAPHITAR parts are engineered for dependability.



GRAPHITAR air/oil seals employed in today's high-speed turbojet engines have established an enviable record for operating dependability. Installed on the main shaft of the turbine, GRAPHITAR seals successfully withstand tremendous shaft speeds and generated heat.

GRAPHITAR bearings in the power reactor pumps of American nuclear submarines have compiled an outstanding record for dependability.

Unusually shaped parts of GRAPHITAR can be molded easily with today's modern techniques. Ears, face slots and outside diameter notches of friction disc above, left, were molded in one operation without need for secondary machining and finishing.

Do you have an application in which GRAPHITAR'S dependability can help solve a tough problem, reduce your costs and improve the operational life of your products? Our engineering staff can help you find out. Our field men can also give specialized, on-the-job consultation. Send for your free copy of Engineering Bulletin #20. Included is helpful information about the properties, characteristics and applications of GRAPHITAR.

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

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TRENDS IN INDUSTRIAL DESIGN

industrial designer finds little new at NATIONAL HOUSEWARES SHOW

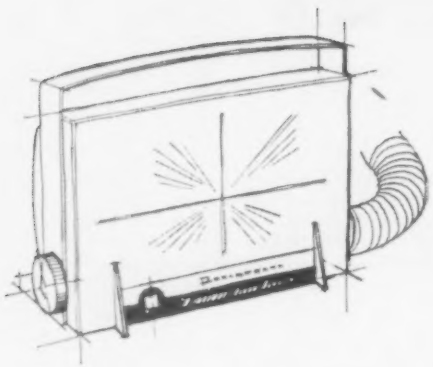
PETER QUAY YANG, *ASID, industrial design consultant, NYC*

Chicago's new lake-front exhibition hall, McCormick Place, provided an architecturally refreshing setting for last month's annual housewares show, but the products displayed inside were disappointing. It quickly became apparent that small-appliance manufacturers are concentrating their promotional efforts on four groups of products: hair dryers, air purifiers, can openers, floor-cleaning equipment. None are new ideas, but each year more companies introduce their versions of these devices.

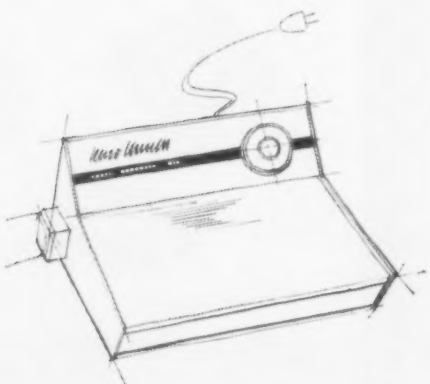
Unfortunately, in most cases the engineers and designers have failed to develop forms capable of expressing the basic functions of these appliances. Most of the shapes and forms are borrowed—sometimes from each other, but frequently from products in unrelated fields.

For example, why should a designer try to make a hair dryer look like a portable radio, when its function would suggest something more like a vanity case? Only one maker drew such a reasonable conclusion. Air purifiers made to look like hi-fi speaker cabinets are likely to prove self-limiting, since they require more grille space than can reasonably be provided on a single housing side to circulate air in sufficient quantities.

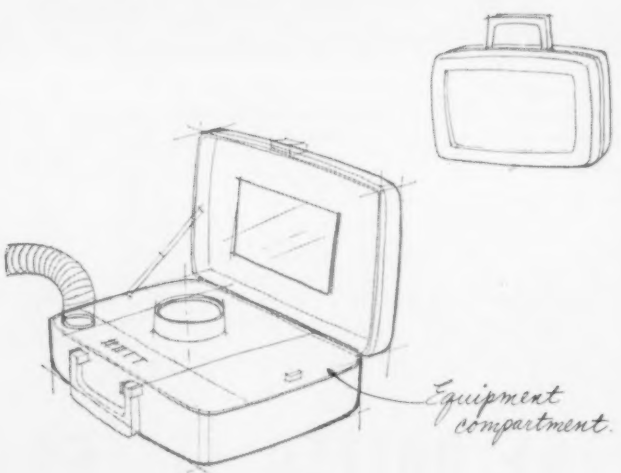
Then there is the company that has used such completely different forms for its five products—all for the same general housecleaning tasks—that none of the exterior parts are interchangeable. The nameplates don't even establish company identity. However, perhaps there was a reason—every one of this maker's machines bore striking resemblance to similar products of other manufacturers!



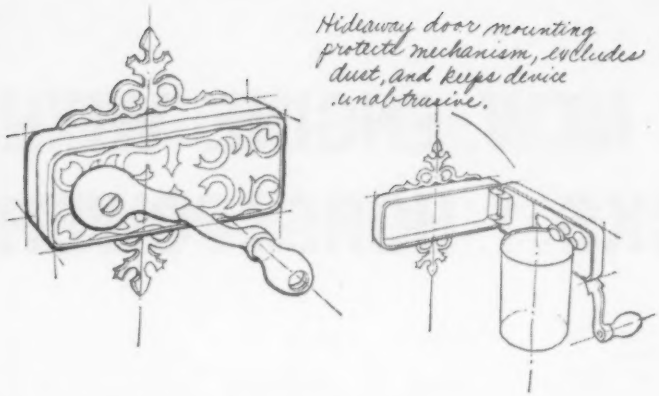
DORMEYER'S HAIR DRYER is slightly overstyled. And, seriously, if it's going to look like a portable radio—why not add one and put an earphone in hair-covering hood?



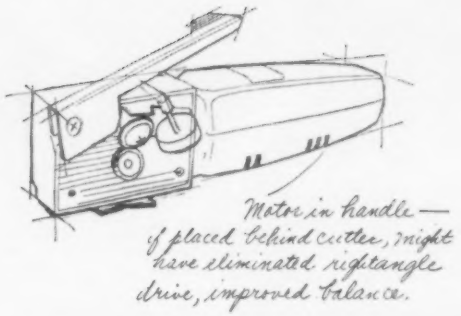
LADY VANITY HAIR DRYER looks a little like a dictating machine, but it's a neat packaging job.



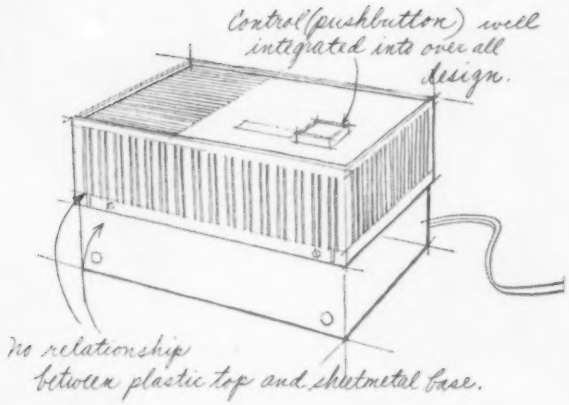
DOMINION'S HAIR DRYER offers most logical design solution. Not only has the look of a vanity case, but can even store some hair- and nail-care equipment.



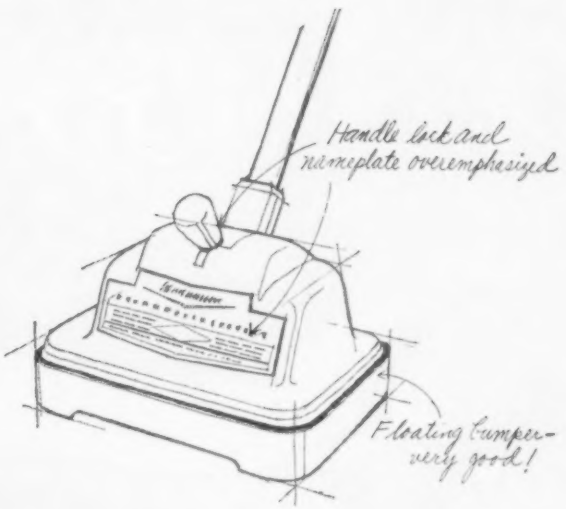
DAZEY'S MANUALLY OPERATED CAN OPENER may be corny, but it's refreshing to see product with a character of its own. Didn't have to be "Early American"—why not a contemporary version, too? Material is wrought iron and provides a finish that requires minimum care.



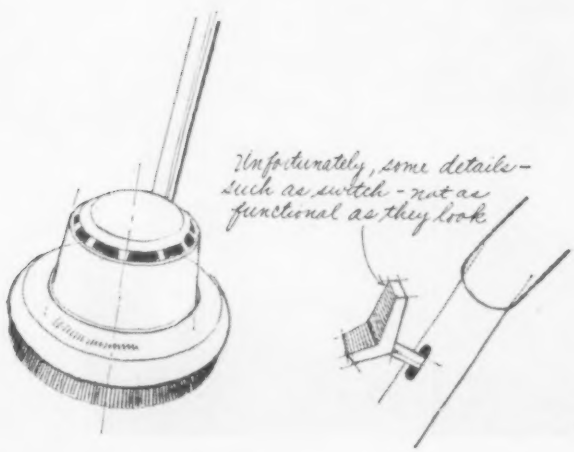
SUPREME'S PORTABLE ELECTRIC CAN OPENER could have been more integrated, but looks like a good idea—maybe the best way to apply power to can opening.



PURITRON'S AIR PURIFIER has all-around grille which clearly establishes its air-circulating function.



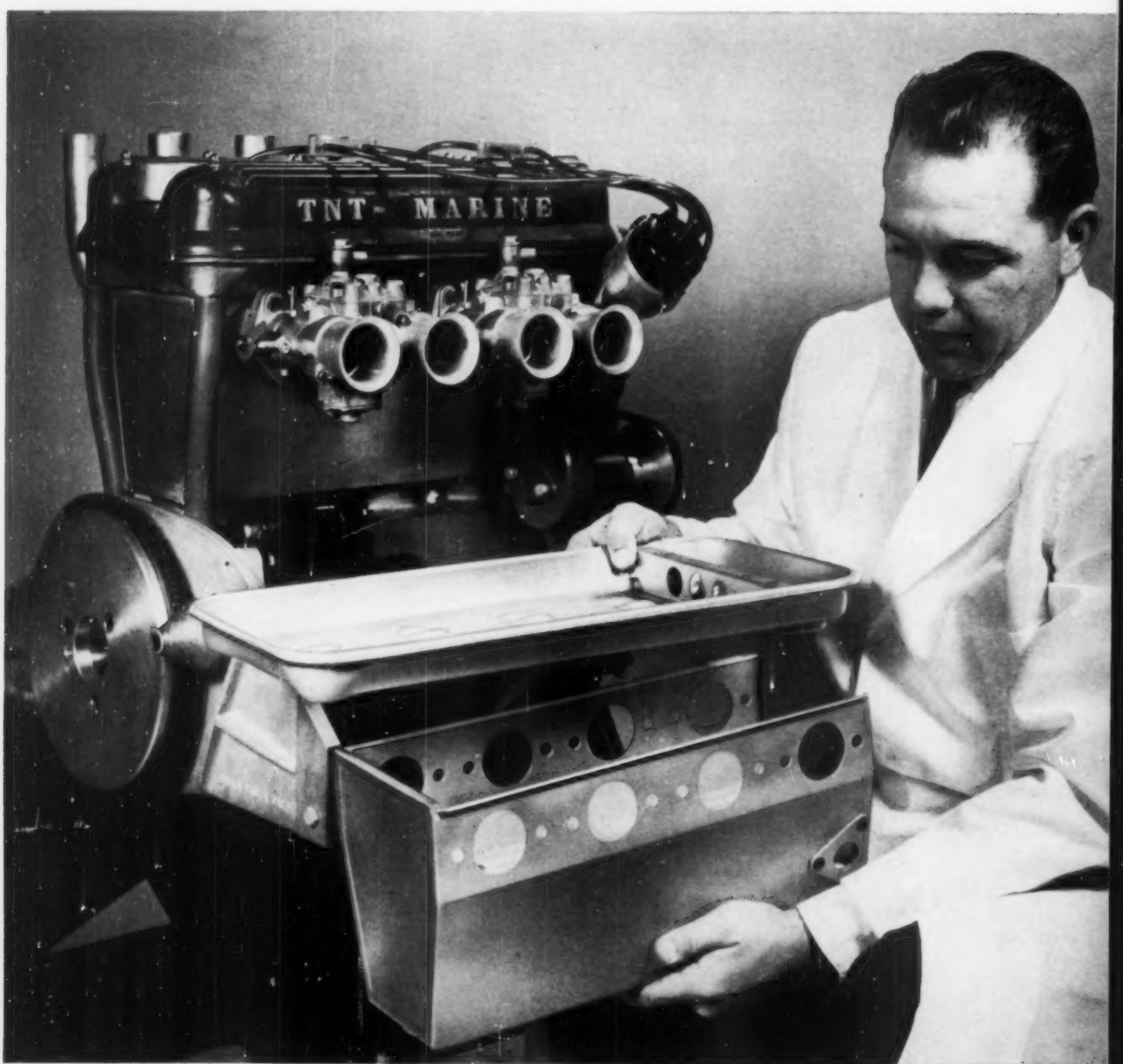
GLAMORENE'S RENTAL RUG CLEANER was only drycleaning type exhibited. Professional equipment should help make the housewife who rents it feel it can do its job well. Lightweight and handles easily.



WESTINGHOUSE FLOOR POLISHER, a single-brush unit, was only one with eccentric rotary motion. Unlike other makes, this one is neat and direct in styling.

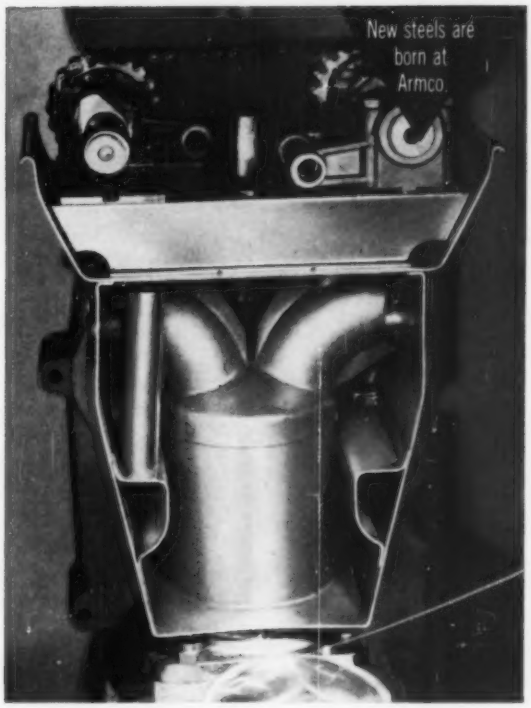
NEW ENGINE WITH PACKS 1 HORSEPOWER

Partly-fabricated stainless steel water jacket and valve pan beside a complete "TnT" Engine. Four-cylinder Tyce/Taylor Engines of several displacements produce from 115 to 175 h.p., depending on needs of marine craft, racing and sports cars.



STAINLESS BLOCK PER POUND

Lightweight cylinder block fabricated from Armco Stainless Steel sheets dissipates heat faster



Cutaway shows stainless parts of the "TnT" Engine: Jacket, coolant galleries, valve pan, cylinders and heads, exhaust and intake ports, and spark plug tubes.

Concentrated power in a lightweight package. That's the new Tyce/Taylor "TnT" Engine produced by Tyce Engineering Corporation, Chula Vista, California. In its 135 cu. in. displacement, this compact power plant generates 175 h.p. It weighs only 175 pounds.

Most unique feature of this engine is a block assembly fabricated from Armco 18-8 Stainless Steel *sheets*. Thin gage components dissipate heat much faster, help hold down engine weight. Uniform wall thickness minimizes "hot spots" and pre-ignition; permits 14:1 compression ratio on regular gasoline. Heat resistance and corrosion resistance of Armco Stainless Steel also are important to the engine's durability.

Consider the special advantages stainless steels can give *your* product designs. Armco produces more than 50 different grades. For full information, call your nearest Armco Stainless Distributor or Armco Sales Office—or fill in and mail the coupon.

Use this label to remind customers your products are made from modern, durable stainless steel.

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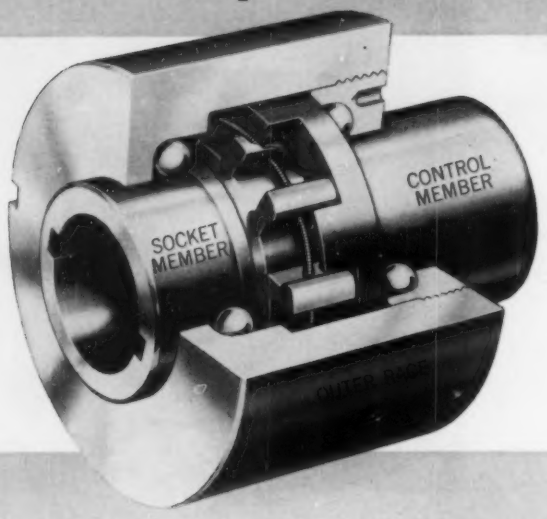
ARMCO **Armco Division**

NOW! a positive positioning device that stops feedback torque without backlash . . .



Rev-Lok devices can efficiently perform a number of application functions such as two-directional drive, positioning, over-running, backstopping, prevention of feedback, etc. Generally, the mounting arrangement used determines which functions are obtained. However, to provide specific details on how Rev-Lok components operate to perform individual functions, sketches and description relating to several typical applications are provided on the facing page.

Now! For any application requiring a power transmission device, that will drive in both directions and instantly stop all feedback torque, the REV-LOK design offers precision performance characteristics and safety factors previously unobtainable in so compact a product.

REV-LOK features a complement of sprags arranged in opposing pairs to automatically and instantly stop feedback in both directions of rotation . . . there is no backlash on output shaft. Also, the design concept provides multi-contact surfaces for greater driving and holding torque, assures equalized radial loading of REV-LOK devices, and evenly distributes wear over all sprags and entire race surface to secure longer life.

The functional versatility of the REV-LOK device is evidenced in its successful use on many diverse applications. Depending on the mounting arrangement employed, REV-LOK devices can be used for: two-directional drive and positive positioning, two-way over-running or backstopping, dual drive or single revolution applications, anti-shock steering, torque limiting, etc.

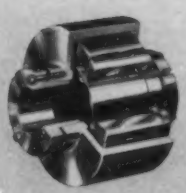
REV-LOK devices have greater torque capacity for their size and weight, and permit higher over-running speeds than any similar product. Current catalog models are available in torque ratings from 90 lbs. in. to 30,000 lbs. in. and with bore diameters ranging from ¼" to 2½". Send for your free REV-LOK catalog—it provides further operational and technical details.

FORMSPRAG COMPANY

23607 Hoover Road, Dept. 115, Warren (Detroit), Michigan

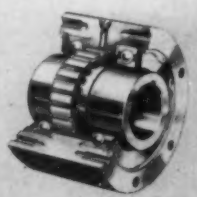
Representation Throughout The World • Precision Power Transmission Products

OTHER FORMSPRAG® PRODUCTS

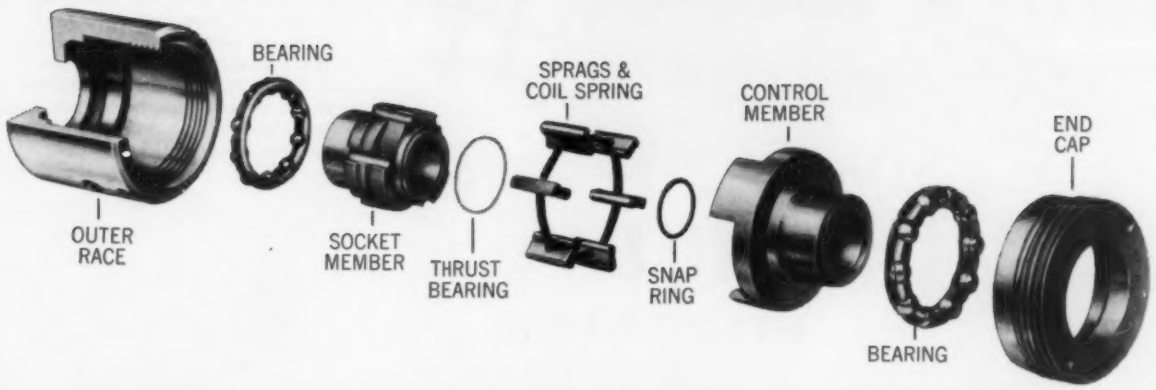


Rawson® Centrifugal Clutches for no-load motor starts and cushioned starting of loads.

Formsprag® Clutches for every over-running, indexing and backstopping application.



...this is REV-LOK



HERE'S HOW REV-LOK DEVICES FUNCTION

With the OUTER RACE held in a stationary or fixed position, torque is transmitted as follows: (Figure 1) The CONTROL MEMBER projects between each pair of opposing sprags and when driving torque is applied to it, each projection first contacts a sprag at point "A" to disengage the sprag from the OUTER RACE. Then, the CONTROL MEMBER drives against the sprag at point "B" to transmit driving torque directly to the SOCKET MEMBER. (Figure 2) When input torque is reversed, the CONTROL MEMBER rotates a maximum of 3° to release the opposing set of sprags and then again drives the SOCKET MEMBER through point "B" on these sprags. (Figure 3) Any input torque from the SOCKET MEMBER is instantly stopped by the wedging of sprags between the fixed OUTER RACE and the SOCKET MEMBER—feedback torque never reaches the CONTROL MEMBER.

(Figure 4) When the SOCKET MEMBER is held stationary and the CONTROL MEMBER is held in a neutral position between the sprags, any input torque applied to the OUTER RACE is instantly stopped by the wedging of the sprags between OUTER RACE and fixed SOCKET MEMBER. However, by applying a relative torque to the CONTROL MEMBER in one direction (Figure 5), the OUTER RACE can over-run in the opposite direction and will also be backstopped. To reverse the direction of OUTER RACE over-running and backstopping, the torque applied to the CONTROL MEMBER is reversed.

(Figure 6) If the CONTROL MEMBER is held in a fixed position and the SOCKET MEMBER is allowed to float freely on a shaft, the OUTER RACE will over-run in either direction. However, if a torque is applied to the SOCKET MEMBER, the OUTER RACE will only over-run in the direction that the torque is applied and will backstop in the opposite direction.

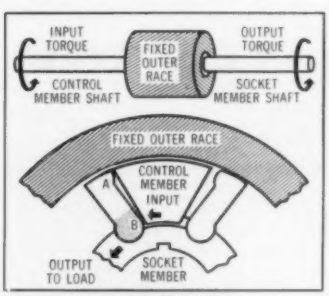


FIGURE 1

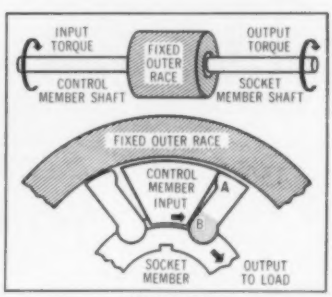


FIGURE 2

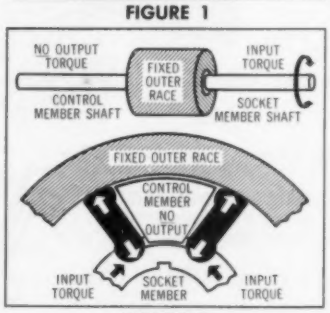


FIGURE 3

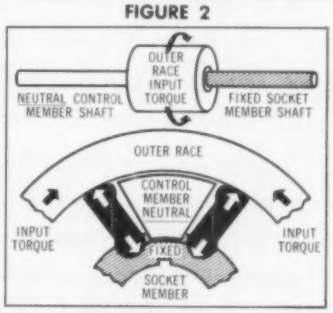


FIGURE 4

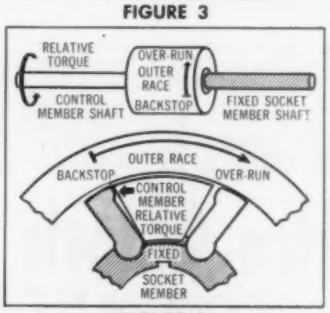


FIGURE 5

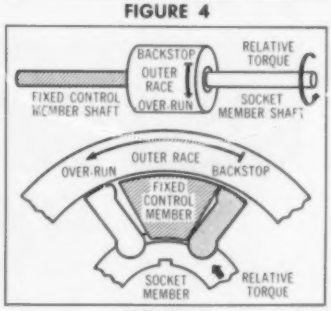


FIGURE 6

WIRE CLOTH

for

FILTERING

SIZING

STRAINING

TESTING

In all metals, in all weaves ... woven to the highest accuracy standard in the industry. You just can't buy a better wire cloth than "NEWARK." Hundreds of meshes, weaves and metals to fit *your* specific need. Years of processing experience to help you pick the right wire cloth for *your* application. Write for Bulletin FC or write us about your problem. Fast deliveries, best cloth, lowest cost when you call on NEWARK.

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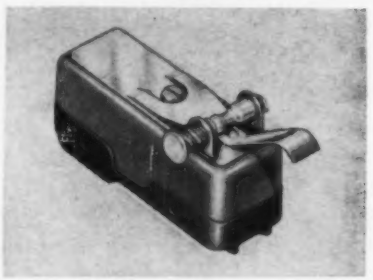
READER TO EDITOR

Switch with a "Cheater"

To the Editor:

The door-interlock switch shown on p 55 of your Jan 16 issue has a serious drawback. It makes no provision for live-circuit testing with the protecting door open—a procedure that is essential when equipment fails and a technician must find the source of the trouble. As a result, the dangerous practice of jumping the contacts or blocking the switch plunger may be resorted to.

Unimax Switch Div of the W. L. Maxson Corp Wallingford, Conn makes



a door-interlock switch with a "cheater" that enables the electrical circuit to be closed for testing. The "cheater" releases when the door of the protective enclosure is reclosed, thus restoring the automatic-cut-out feature of the interlock. The switch is the Type 2HBM-1.

C W METCALF
Sharon, Mass.

Ivan and Sam

To the Editor:

I strongly object to your editorial in the Dec 12 '60 issue, p 55, wherein the implication is that Ivan and Sam differ only in idea and "toughness." This is pale pink hogwash. Ivan doesn't just "take 'em over—he exterminates 'em—by the millions—many of them relatives. In short, let's not kid ourselves about the third feller who doesn't exist; let's make a basic decision—tyranny or freedom—and if we are as bright as editors are supposed to be, borrow Sam's ham and start blowing it for him.—PETER B KELLY
Pasadena, Tex

Placing the Decimal

To the Editor:

Harvey S. Pardee's method of placing the sliderule decimal point (Oct 10 '60, p 65) can be further shortened. His third step involves mentally computing the result of the first digits. With a lengthy calculation this in itself becomes a second problem.

The answer is to add a "sub" every time a division is made on the sliderule with the rule sticking out to the left, and add a "supe" every time a multiplication is made with the rule sticking out on the left.

The solution is then immediately found without any further mental computations.

—C R J FLEMING
Manchester, England

Snap Goes the Mousetrap

To the Editor:

Your editorial, "The Better Mouse," (Nov 28 '60, p 27) is fine, but I doubt that it's as simple as all that. The utilitarian approach is not, in the last analysis, as effective as it purports to be. It appears that much utilitarian thinking has gone into the making of the conditions we presently have, and what are the results? An attempt at detached honesty would get all of us farther than the mere principle of finding the dollar sign in every equation.

Admittedly, if there is an answer it's bound to be complex, because we have created a complex civilization. It is of necessity difficult to give a simple answer to a complex question.

Was it not old Henry Ford who said that the best way to acquire no riches was to think of money permanently? A good deal of effort has been put into the promoting of technological progress, and we are not better off. In fact, we are worse off.

—M Wulfinghoff
Erlanger, Ky

Creativity = Jobless Engineers

To the Editor:

Your article "Creativity—a New Appraisal" (Dec 12 '60, p 79) was wonderful. The only trouble with your recommendation is that it would throw half the engineers in industry out of work. You say, "As an individual, man is capable of genius, never as a project team." A project team is an organization of talent, so that the real contributors can be hidden. . . . . in order for management to assume credit.

—H J Reinig

COMING EVENTS

FEBRUARY

26-March 2 . . . . American Institute of Mining, Metallurgical & Petroleum Engineers, Chase Park Plaza & Ambassador Hotels, St. Louis

MARCH

9-10 . . . . Institute of Radio Engineers with AIEE & IAS, 2nd Symposium on Engineering Aspects of Magneto-hydrodynamics, Univ of Penna, Philadelphia

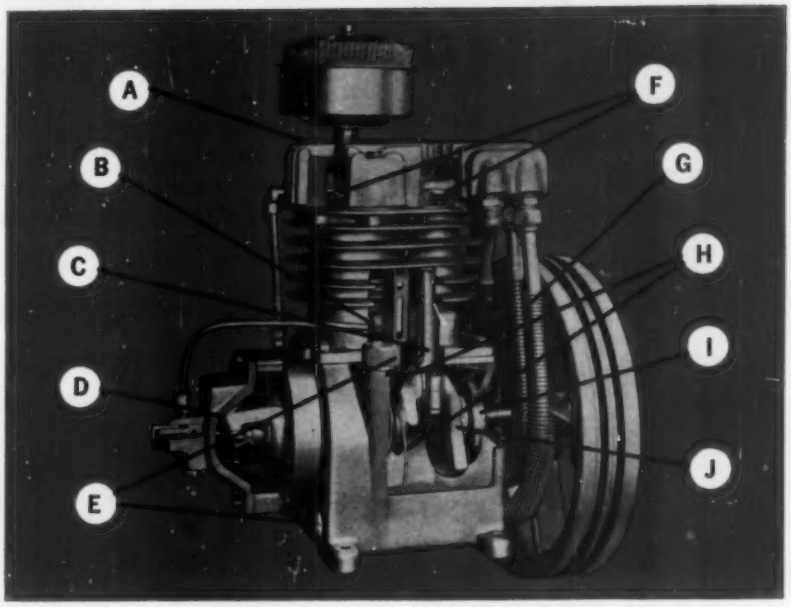
12-16 . . . . American Society of Mechanical Engineers, Aviation Conference, Statler Hotel, Los Angeles

14-16 . . . . Society of Automotive Engineers, National Automotive Meeting, Sheraton-Cadillac Hotel, Detroit

20-23 . . . . Institute of Radio Engineers, International Convention, Waldorf-Astoria Hotel & NY Coliseum, NYC

For a current listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure, R 32.

For Dependable Air Power Depend on Kellogg-American AIR COMPRESSORS



These are only a few of many quality features:

- IMPROVED HEAD DESIGN—Gives higher efficiency. Large direct air passages permit free flow of air, reducing pressure drop; greater cooling and valve areas.
- WRIST PIN BEARINGS — Roller type to withstand greater bearing load.
- CONNECTING RODS—Designed for force oiling. Automotive type insert bearings.
- CENTRIFUGAL UNLOADER—An efficient, durable device for pressure relief to insure no-load starting.
- OIL GAGE AND FILLER — Oil level is quickly checked with new look-through gage. New larger oil fill opening is located for easy, quick lubrication.
- MULTIPLE VALVES — High efficiency, wafer-type valves (with minimum of parts) have removable seats and are designed for long service life.
- IMPROVED INTERCOOLERS—Larger radiating fins. Pressure drop reduced by higher air flow capacity.
- LUBRICATION SYSTEM — Ring lubrication. Positive controlled force-feed oiling to every wearing surface.
- MAIN BEARINGS—Tapered roller bearings. Crankshaft supported at both ends.
- CRANKSHAFT — Drop-forged, counterbalanced, with super-finished bearing surfaces.

Kellogg-American's superior engineering, workmanship and rugged construction combine to assure long trouble-free life and efficient low-cost performance.

Choose from over 250 different models, from ⅓ through 20 HP, including bare compressors, base-plate mounted, and tank-mounted units. Available in both single and two-stage models.

For detailed specifications, write to:

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PRECISION-FORMED
METAL COMPONENTS

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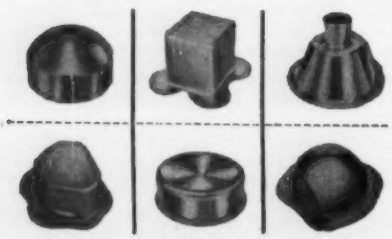

Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

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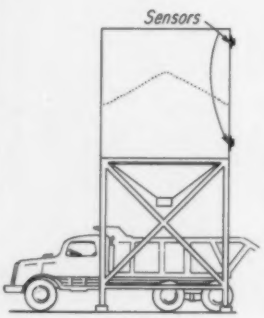
WHY DON'T THEY R&D..?

. . . a thermoelectric generator for automobiles. Waste engine heat could be turned to useful purpose with help from the new semiconductor devices that generate electricity by the Seebeck effect. These thermoelectric generators are still in the experimental stage, but a unit that would develop the necessary charging current for an automobile battery should not be too far beyond the capability of existing devices. Besides the advantage of not draining power from the engine, this kind of generator would be quiet, cause no radio interference, no brush wear, and have long life. Though it would not begin generating until after the car had been running a short time, it would continue to charge the battery after the engine was stopped. With ignition supplied by the newly developed piezoelectric "spark pump," (*PE—Oct 24 '60, p 17*) the car could be push-started even if the battery was dead. —R MARIE



. . . a simple, inexpensive device for measuring the level of loosely packed, dry material in storage bins. Many devices have been tried but none are entirely satisfactory for measuring the level of grain, for example, in a large storage bin. The lenses of photoelectric cells dust over; ultrasonic devices are too expensive; load cells in the legs of the bin are not sufficiently accurate; float and diaphragm types are too difficult to install. According to a manufacturer of storage bins, there is a large market for a simple, dependable, inexpensive device. —G B STONE

. . . a small, battery-powered traveling alarm clock for light sleepers who are annoyed by the ticking of mechanical clocks. The clock mechanism could be driven by an electrically excited tuning fork like the recently announced Bulova Accutron wristwatch (*PE—Oct 24 '60, p 50*). The alarm would be driven by amplified signals from the tuning fork. It would not need to be wound and would need no ac power outlet. A small battery should last several years. —R BERG

. . . new uses for copper. The Copper Products Development Association, to promote more interest in copper, has several suggestions: Why not incorporate a copper-foil underlayer in counter-top materials to carry away heat? Or how about making shingles for homes from asphalt-backed copper sheet? Prestressers for concrete is another possibility—copper has lower modulus of elasticity, therefore one-third the prestressing loss of steel. Brake drums made of a copper-base alloy would dissipate heat faster, minimizing brake fade. Copper liners for large-dia concrete pipe would prevent attack by acidic fluids. High-temperature insulation for copper wire could be made by treating the wire surface with a suitable chemical—the reaction products would coat the wire with a refractory insulation which would be strong and reasonably ductile.

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

Another New Fastener Idea From Parker-Kalon

The New PARKER-KALON
W-POINT Socket Set Screw

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Now you can get the highest degree of holding power ever attained!

30% more back-out torque 50% more resistance to vibration 50% more resistance to rotary slippage

Like many important advances in technology, the Parker-Kalon W-Point concept is simple and straightforward. In use, its superior performance and holding power will be demonstrated to your own satisfaction. Available from P-K distributors at no increase in cost.

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Heads are of uniform diameter. Threads Class 3A tolerance. Available in standard sizes from #0 to 1½" diameter in alloy steel and from #0 to ⅜" diameter in stainless steel. Available in 1936 and new 1960 "Pre-Lode" Series.

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Precision Class 3A threads, standard in Cup Point from #0 to 1" and in Flat, Oval, Cone and Half-Dog Points from #4 to ⅜". Cup Point also available in stainless steel.

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Threads Class 3A tolerance. Heads are concentric with body for uniform, accurate assembly. Available in standard sizes from ¼" to ¾" diameter.

FLAT HEAD SOCKET CAP SCREWS

Seats flush when countersunk. Heads have uniform 82° angle. Threads Class 3A tolerance. Special alloy steel, heat treated. Available in standard sizes from #4 to ¾".

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Heat treated alloy steel. Accurate hex sockets make for non-slip driving, prevent mutilated heads. Threads Class 3A tolerance. Standard sizes from #4 to ⅝".

SOCKET SEMS

P-K is the only fastener manufacturer to provide socket Sems, to meet your needs for precision-made socket head cap screws with split ring washers.

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Made of special analysis alloy steel, scientifically engineered. Heat treated for optimum physical characteristics. Made to close tolerances.

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Now you can get all of these famous P-K® quality socket screws with or without

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Look at that groove! It's P-K's secret weapon against vibration. Filled with Polycap nylon-type polymer, it solves a thousand and one problems where vibration is present . . . where adjustment is required . . . where reuse is a factor, over a wide temperature range.

- *Provides higher resistance to shock*
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- *Superior thread engagement and locking force*
- *Eliminates need for lock washers, safety wires*
- *The Long-Lok insert is available on P-K Socket Head Cap Screws, Set Screws, Flat Heads, Button Heads, Shoulder Screws and Pipe Plugs.*

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You get **MORE THAN A MOTOR** with General Electric's Form G . . . for example . . .

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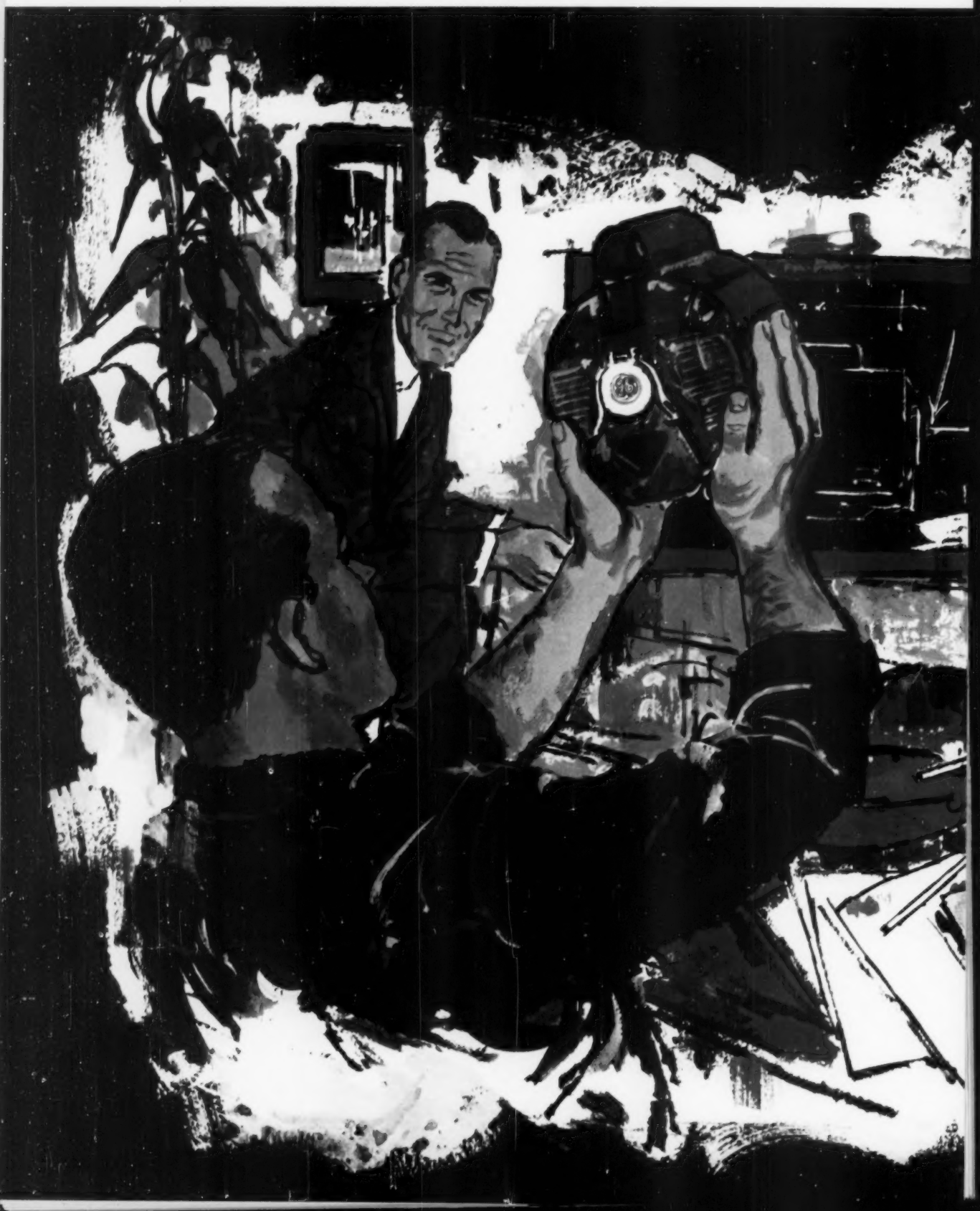


Aid

Are you taking advantage of all the motor knowledge available to you? A phone call will bring a General Electric application engineer to help solve your motor application problems. He's not only an expert on G-E Form G fhp motors, but in all phases of applying them. He can bring years of motor experience and knowledge to bear for you. Why not try him?

In addition to expert application assistance, you get these **MORE THAN A MOTOR** benefits with General Electric Form G motors: *Years-ahead Design Leadership . . . Versatility Personified . . . Ease of Assembly . . . On-time Delivery . . . Fast, Local Service.*

You receive these *added values* at no extra cost. So why settle for less?

Form G fhp motors are available in NEMA 48 and 56 frames. For more information, call your G-E Sales Engineer or write to Section 721-07, General Electric Co., Schenectady 5, New York.

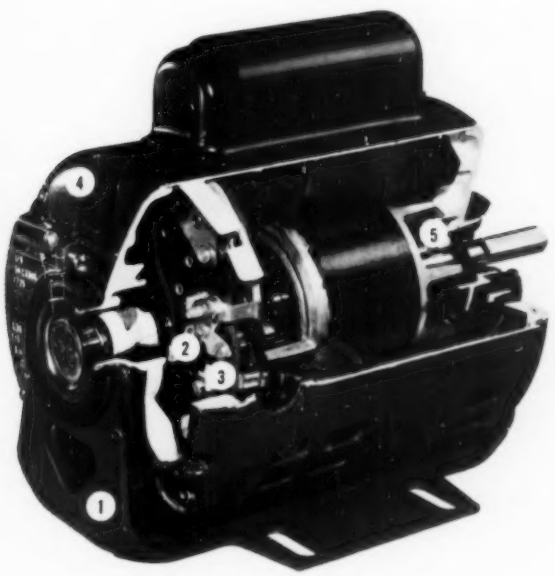
THESE FORM G MOTOR VERSATILITY FEATURES MEAN GREATER DESIGN FREEDOM FOR YOU

1. MOUNTING VERSATILITY—Both solid and resilient cradle bases permit rotation of Form G motors within base to meet design and space requirements.

2. FAST ROTATION CHANGE—Just interchange two leads; reverse rotation in seconds. This eliminates duplicate stocks for just a change in rotation.

3. FAST VOLTAGE CHANGE—Sliding plates on terminal boards allow change from 115 to 230 v operation (or vice versa) in one-fifth the time.

4. EASY, DIRECT MOUNTING—Mount Form Gs without expensive machining or brackets. Close end shield tolerances allow mounting of motor with through-bolts.



5. ALL-ANGLE OPERATION—All-angle sleeve bearing and positive oil retention system allow you to mount standard Form G motors in any position.

6. COMPLETE LINE—Over 850 basic models—and thousands of variations—mean there's a standard Form G motor for your product's *exact* requirements.

Progress Is Our Most Important Product

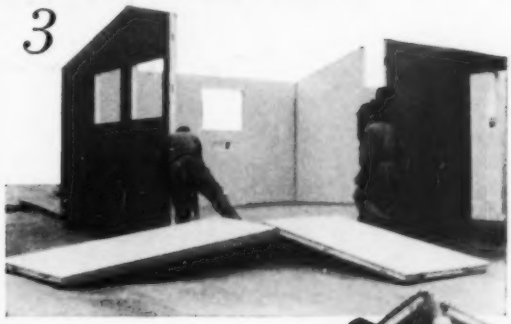
GENERAL ELECTRIC

Born to live a short life,
this missile guidance component must perform as if it had to last forever! CDF molded this part under high pressure from glass fabric epoxy laminate to meet rigid military electro/mechanical requirements.
Result: a panel with excellent electrical insulating properties and high mechanical strength that provides significant savings in space and weight, helps minimize vibration.

CDF **CONTINENTAL-DIAMOND FIBRE**

CONTINENTAL-DIAMOND FIBRE CORPORATION, NEWARK, DELAWARE • A SUBSIDIARY OF THE Budd COMPANY

how to build a house in a day...



1 Floor panels are locked to joists laid on permafrost ground.

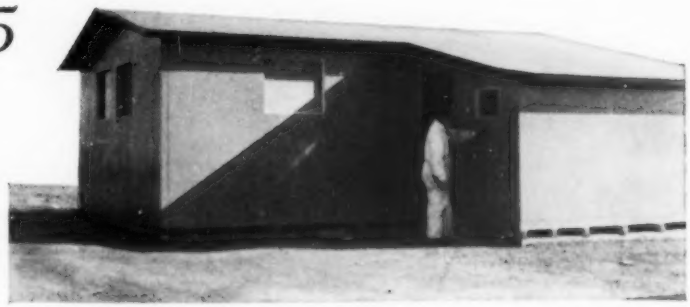
2 Doorway is first wall panel to go up. It locks to floor.

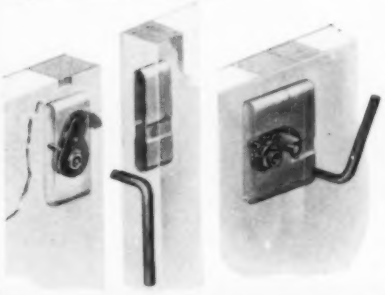
3 Walls and partitions lock to floor and to each other.

4 Roof panels go on last. This takes about three hours.

5 Complete in 7 hours! Floor, walls, roof panels—It's all done with Simmons Dual-Lock fasteners.

Standard Dual-Lock withstands 2500-lb. tension; may be modified for high-load applications to 4500 lbs.





- This house is put up in a day—and can be taken down in half a day!
- Key to quick assembly-disassembly is the Simmons Dual-Lock.

Dual-Lock is a high-load, positive-locking structural fastener perfectly adapted to panel fastening of demountable shelters, shipping containers, covers, cowlings... and to all butt-joint fastening jobs. It can be recess-mounted as in the application pictured, or surface-mounted on sheets or panels. Locks with heavy closing pressure, with very light pressure required on the key.

Arctic Units, Ltd., Toronto, Canada, is putting up 90 "Eskimo Houses" on the DEW Line. Panels, including roof, are plywood-covered styrofoam designed for insulation against Arctic cold.

WRITE FOR CATALOG 760. Complete details of Dual-Lock and other dependable quick-operating Simmons Fasteners with unlimited money-saving applications.

- Samples and engineering service available upon request.

SIMMONS FASTENER CORPORATION

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Tool and Hardware Manufacturers Use Malleable for the Parts They Guarantee...

"Guaranteed Against Warping or Breaking" is the seal of quality often found on tools and hardware made of Malleable iron. Frequently Malleable components are guaranteed while the other materials in the same tools are not.

Proven performance superiority has induced many tool and hardware manufacturers to switch to Malleable castings so they, too, can guarantee their products. At the same time, they often reduce their costs. How? Because Malleable provides more strength per dollar than any other metal; Malleable is the most machinable of all ferrous metals of similar properties; Malleable is truly outstanding for its toughness, ductility, castability and corrosion resistance. While Malleable's natural appearance is attractive, a wide variety of finishes can be applied for added customer appeal.

Improve your products by using Malleable castings. Check with any Malleable producer that displays this symbol —

MEMBER
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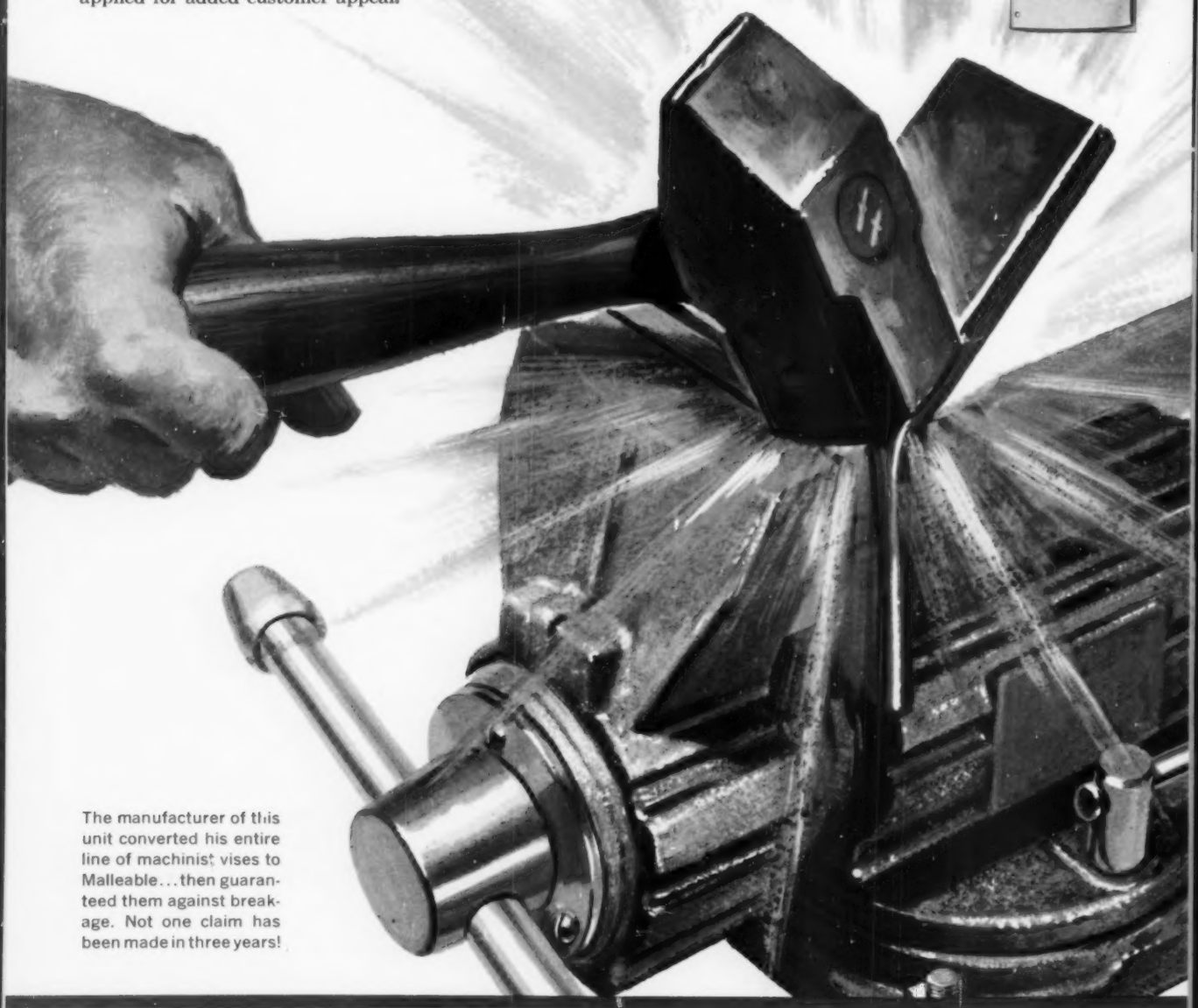
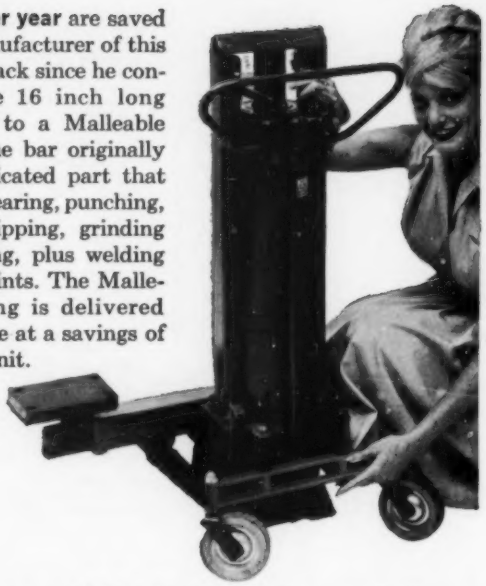
CASTINGS COUNCIL

Profitmaking Ideas are yours free in our Data Unit No. 114, available from any member foundry, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.



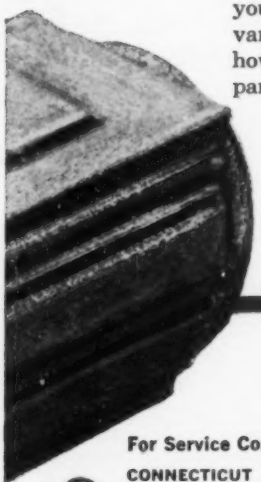
The manufacturer of this unit converted his entire line of machinist vises to Malleable... then guaranteed them against breakage. Not one claim has been made in three years!

$10,000 per year are saved by the manufacturer of this hydraulic jack since he converted the 16 inch long caster bar to a Malleable casting. The bar originally was a fabricated part that required shearing, punching, sawing, chipping, grinding and reaming, plus welding at eight points. The Malleable casting is delivered ready-to-use at a savings of $2.68 per unit.



The wide range of Malleable's properties permits its use in hundreds of tool and hardware applications. Besides the examples shown here, Malleable is used for load binders, chain hoists, hinges, many kinds of clamps, pliers, trailer hitches, jack screws, gun frames, fence fittings, casters, brackets and pipe threading and cutting tools.

When you're interested in high quality and long life, Malleable gives your products many competitive advantages. We'll be glad to show you how. Write or call one of the companies listed below.



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INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
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IOWA
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Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

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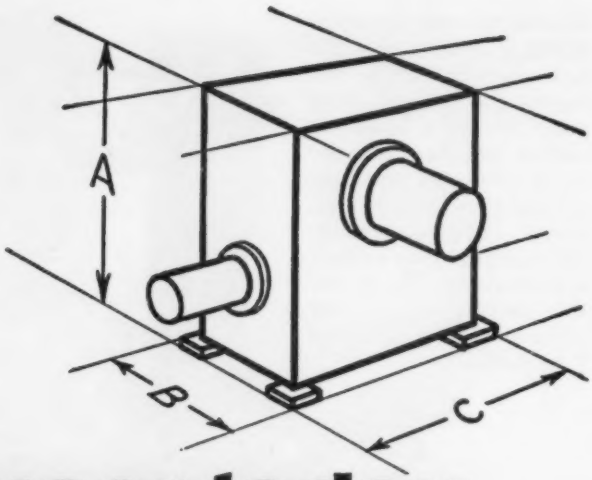
Do-It-Yourself...



Let's design a speed reducer today

So you can't find a speed reducer to fit your latest brainchild without ruining the design? Doggone manufacturers all build reducers too big to fit into those few cubic feet you've got left for the reduction unit back behind the double-ended dingbat?

Revolt! Design your own! Show 'em!

By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

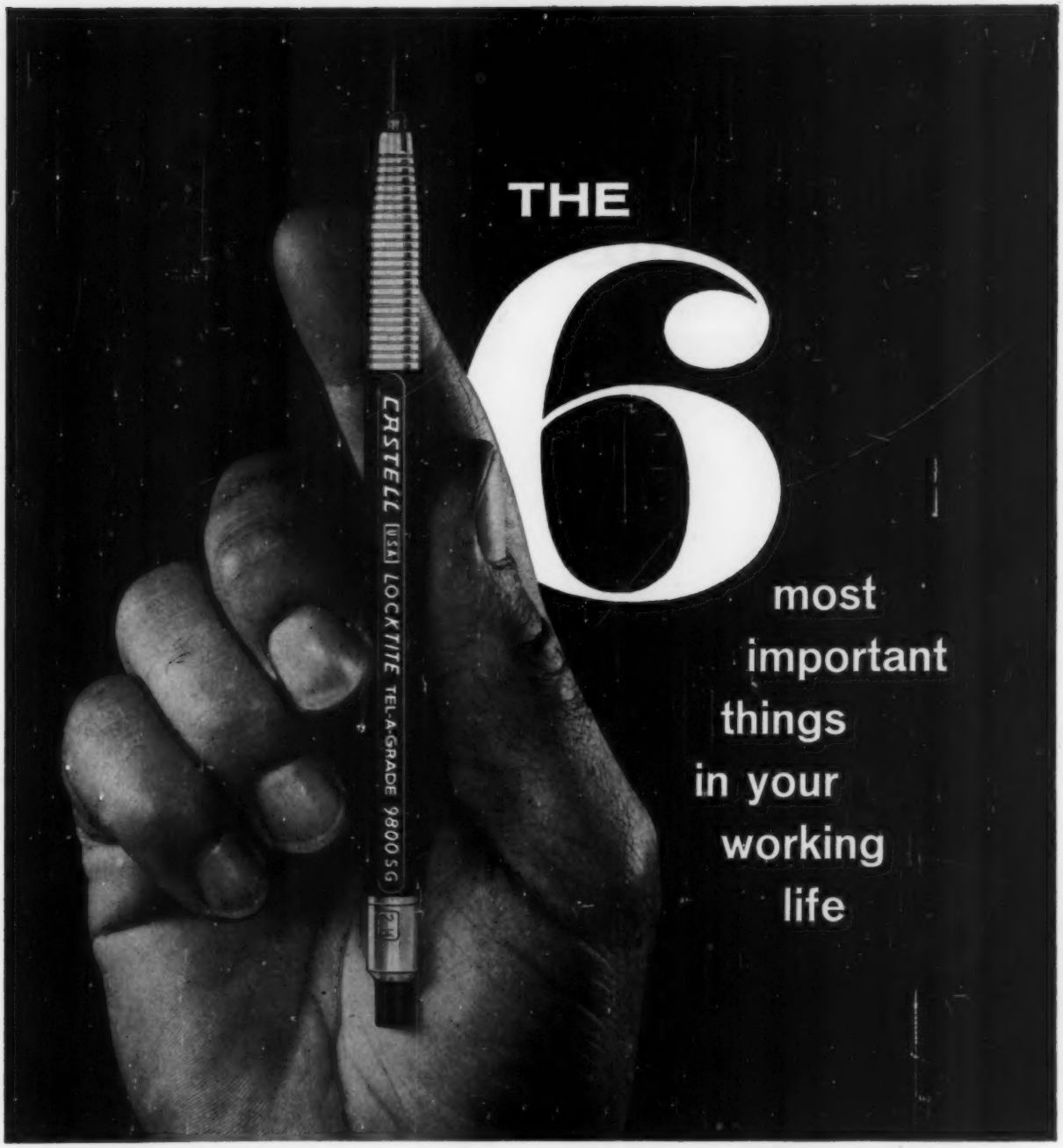
Does this reduce load capacity? No sir! You can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.



The 6 most important things in your working life are your five skilled fingers and your A.W.FABER #9800 SG LOCKTITE Tel-A-Grade Lead Holder.

LOCKTITE becomes a part of your creative process. The no-slip functional grip gives you smooth traction and practically banishes finger fatigue. Gun-rifled clutch holds the lead like the jaws of a bull dog. Unique indicator reveals the degree in use at a glance. Carries ironclad 2-year guarantee. A.W.FABER will replace the entire holder at no charge if any part wears out in normal usage. Yes, you can buy cheaper lead holders, but can you afford to let pennies stand between you and your perfect working tools? Buy quality —buy LOCKTITE, call your dealer today.

Castell Drawing Leads #9030, *are of the identical quality and grading as world-famous Castell wood pencil ■ Usable in all standard holders, but a perfect mate for Locktite ■ Draws perfectly on all surfaces, including Cronar and Mylar base films ■ Available in all degrees from 7B to 10H, and in a kaleidoscope of colors ■*

FABER-CASTELL

A.W.FABER-CASTELL
Pencil Co., Inc., Newark 3, N. J.

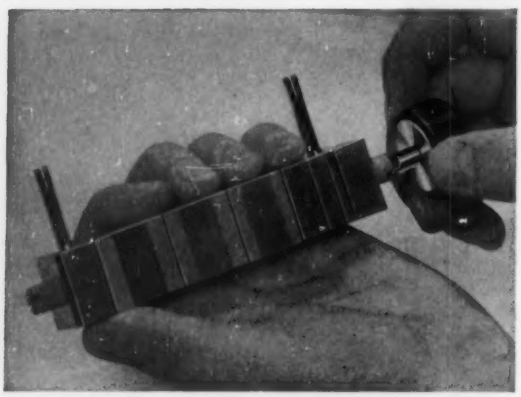
Our Bicentennial year—1761-1961
200 years of uninterrupted
manufacturing experience.

CIRCLE 41 ON READER SERVICE CARD 41

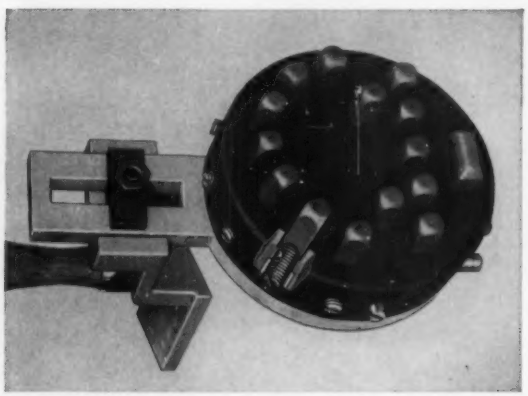
Practical Design Tips

No. 5 of a series

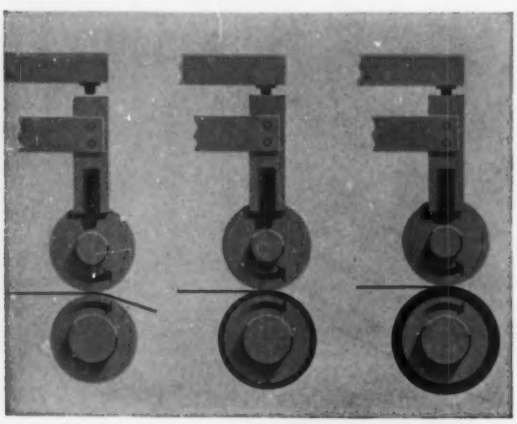
Cost conscious product designers are finding new uses for Vlier products in all types of original equipment. Simple applications such as shown below are saving hundreds of dollars. Examine your drawings and products today and see where these inexpensive, off-the-shelf parts can lower your costs.



TORQUE APPLIED TO ASSEMBLE PRECISION GAGE BLOCKS is limited by this modified Vlier Torque Thumb Screw. Ground screw point mates with assembly screw; prevents overtightening with resultant damage to blocks. Torque Screws are available in four types, many thread sizes, lengths and end pressures.



SPRING-LOADED BALL PLUNGERS HOLD MARKING STAMPS IN POSITION, yet allow them to move freely when struck. Ball Plungers are threaded into metal inserts molded in rubber. Binding action of rubber prevents plungers backing off. Plungers come in six models; sizes from #4-48x3/16 to #5/8-11x1; 18 end pressures.



LIMIT SWITCHES ON THIS TEXTILE DRAWING FRAME ARE PROTECTED by Vlier Spring Plungers. Bunching of broken threads causes rolls to lift, actuating limit switches which automatically shut off the machine. Plungers permit normal operation of the switches, but limit over-travel of switch actuating arm. Spring Plungers are available in four models, 50 sizes, various end pressures.

FREE IDEA BOOKLET! This informative 16-page booklet shows how other original equipment manufacturers are profiting from the use of standard Vlier parts. It may suggest ways you can save, so write for your copy today.

VLIER
Engineering Corporation
Subsidiary of Barry Controls, Inc.
8900 Santa Monica Blvd. • Los Angeles 46, California

IMPACT!

This is a "warhead". It's the front end of a carrier which darts through a pneumatic tube system at speeds up to 20 mph, and is subject to frequent shocks and impact. There's a story behind the choice of LEXAN® polycarbonate resin for this new design . . .

Formerly, destinations were set by contacts along the entire body of the carrier. Engineers of Airmatic Systems Corporation, Saddle Brook, New Jersey, reasoned that if all the control elements could be fitted into a small impact- and wear-resistant head, the rest of the carrier could be designed for easy maintenance and quick replacement. Many plastics had the required dielectric strength, but none could measure up to LEXAN resin's combination of good electrical properties, excellent dimensional stability and extremely high impact strength. LEXAN resin actually withstands over 12 foot-pounds per inch of notch — an impact strength attained by no other plastic!

The new warhead is injection-molded of black LEXAN resin by Berkeley Engineering & Manufacturing Co., Berkeley Heights, N. J. Now when wear and tear take their toll, the transparent carrier body is easily replaced, since it has no control elements. Also, body length can be varied to suit customer needs, and carrier weight is reduced. Printed circuits and compactly arranged brushes and control plates are used. The new design is more attractive, more practical, less costly. And—LEXAN resin warheads have proved in field tests to last longer than the old control units.

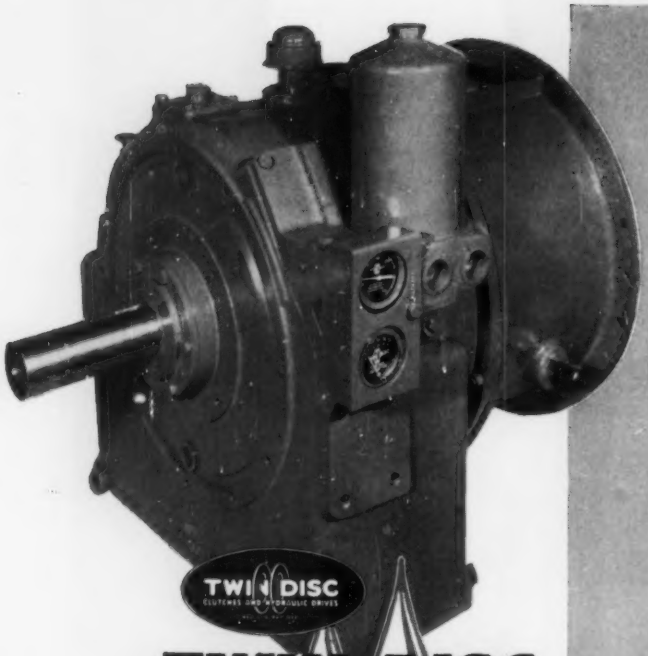
G.E. LEXAN polycarbonate resin has raised the quality of many designs to new levels. It has been reduced in price approximately 40% over the past year! Can this tough, new thermoplastic help you? Send for design literature.

LEXAN®
Polycarbonate Resin

GENERAL ELECTRIC

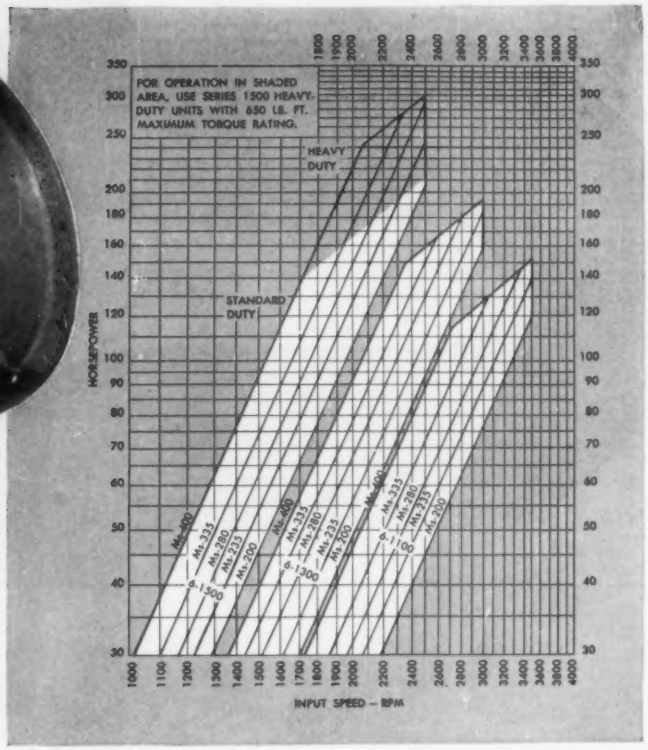
Chemical Materials Dept., Section PE-21, Pittsfield, Mass.

CIRCLE 43 ON READER SERVICE CARD



TWIN DISC

Torque Converters


FOR OPERATION IN SHADED AREA, USE SERIES 1500 HEAVY-DUTY UNITS WITH 650 LB. FT. MAXIMUM TORQUE RATING.
HEAVY DUTY
STANDARD DUTY
HORSEPOWER
INPUT SPEED — RPM

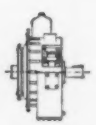
This chart gives horsepower and speed ratings for all Twin Disc Single-Stage Converters. Note that the 1500 Series is furnished in standard and heavy duty capacities. The figure "6" preceding the series number refers to the type of circuit.

"Stripped" or cartridge-type units for OEM in-line design

Nine models—11", 13" and 15" sizes.
Torque ratings from 235 to 650 lb.-ft.
Three types: Converter only; converter with oil-actuated disconnect clutch; and converter with disconnect clutch and lock-up direct drive clutch.

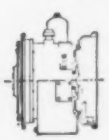
Basic power take-off units

Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.



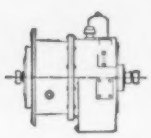
Spacer units for connection to transmissions

Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Available with dummy flywheel for automotive type clutches.



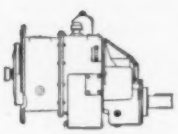
Units equipped with front-end disconnect clutch

Four models—13" and 15" sizes.
Single or double plate clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel for shovels and cranes.



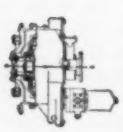
Units equipped with disconnect clutch plus 2:1 ratio reduction gear

Three models—13" and 15" sizes.
Single or double plate 11" clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel.



Sumpless PTO units for power-shift transmissions

Three models—13" and 15" sizes.
Live power take-off for auxiliary drives.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Optional: Rubber block input drive.



SINGLE-STAGE TORQUE CONVERTERS

25 models

Virtually any single-stage torque converter requirement can be met with one of Twin Disc's standard rotating-housing units. The scope of the Twin Disc line can be seen from the summarized listing at left.

Each converter size—11", 13" and 15"—has five interchangeable impellers which vary with respect to blade number and pitch so that each has a different torque absorption capacity. This exclusive Twin Disc design feature provides a 2:1 horsepower spread for each converter series. It insures correct matching of converter to engine and also permits a subsequent increase in engine horsepower without dimensional changes in the torque converter.

Twin Disc Single-Stage Converters are available as "industrial" (self-contained) units or as "stripped" (cartridge type) units for incorporation into OEM transmission designs. Complete details are contained in Bulletin 510. For your copy, write TWIN DISC CLUTCH COMPANY, Hydraulic Division, Rockford, Illinois.

CELANESE POLYMER COMPANY

Designed in Fortiflex... for PHILCO-Bendix

This blow-molded unit stores and dispenses detergents and bleaches in Philco-Bendix Duomatic® washer-dryer combinations. Molded of Celanese Fortiflex B-50-20, it is corrosion-free, light, strong, and easily cleaned with boiling water.

Fortiflex is an easily molded, tough, rigid material, which provides unusual freedom in design. It offers outstanding heat, chemical and stress-cracking resistance and can often replace metals and other materials in components, with product improvement and cost savings.

Write for technical data on Fortiflex, outlining your application, to: Celanese Polymer Company, Dept. 103-2, 744 Broad Street, Newark 2, N. J.

Celanese® Fortiflex®

Celanese Polymer Company is a Division of Celanese Corporation of America.
Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver.
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue. N.Y. 16.

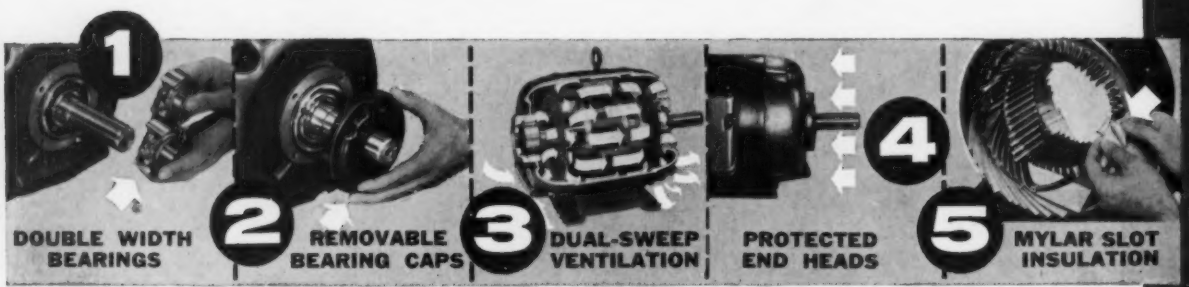
Celanese POLYMER

CELLULOSICS . . . POLYETHYLENES . . . POLYESTER RESINS . . . CELLULOSIC FLAKES

CIRCLE 45 ON READER SERVICE CARD

WHICH R&M MOTOR FEATURE WILL ADD MORE TO YOUR PRODUCT'S

COMPETITIVE ADVANTAGE?



All these outstanding features—*yours at no extra cost*—contribute to R&M's dependable performance, easy maintenance and long life. Fully sealed double-width bearings have extra-large reservoirs containing grease selected to resist dust, temperature, humidity and high speeds. Bearing inspection and relubrication are easy. Bearing cap on each end head comes off quickly when four bolts are removed. Bearing seal, held by removable snap rings, is also easily removed. "Dual-Sweep" ventilation greatly prolongs motor life with high-velocity cooling and cleaning. Tandem fans—one pushing, one pulling—create end-to-end ventilation that eliminates "dead" areas. Venturi baffles direct air over and around end coils. One-piece shrouded end heads give full-height protection against moisture and falling objects. Mylar* laminated to rag paper insures positive slot cell insulation because of its excellent dielectric qualities (8 times that of conventional insulation). Rag paper backing provides cushion against abrasion and puncture. Get complete information . . . write today for Bulletin 520-PRE

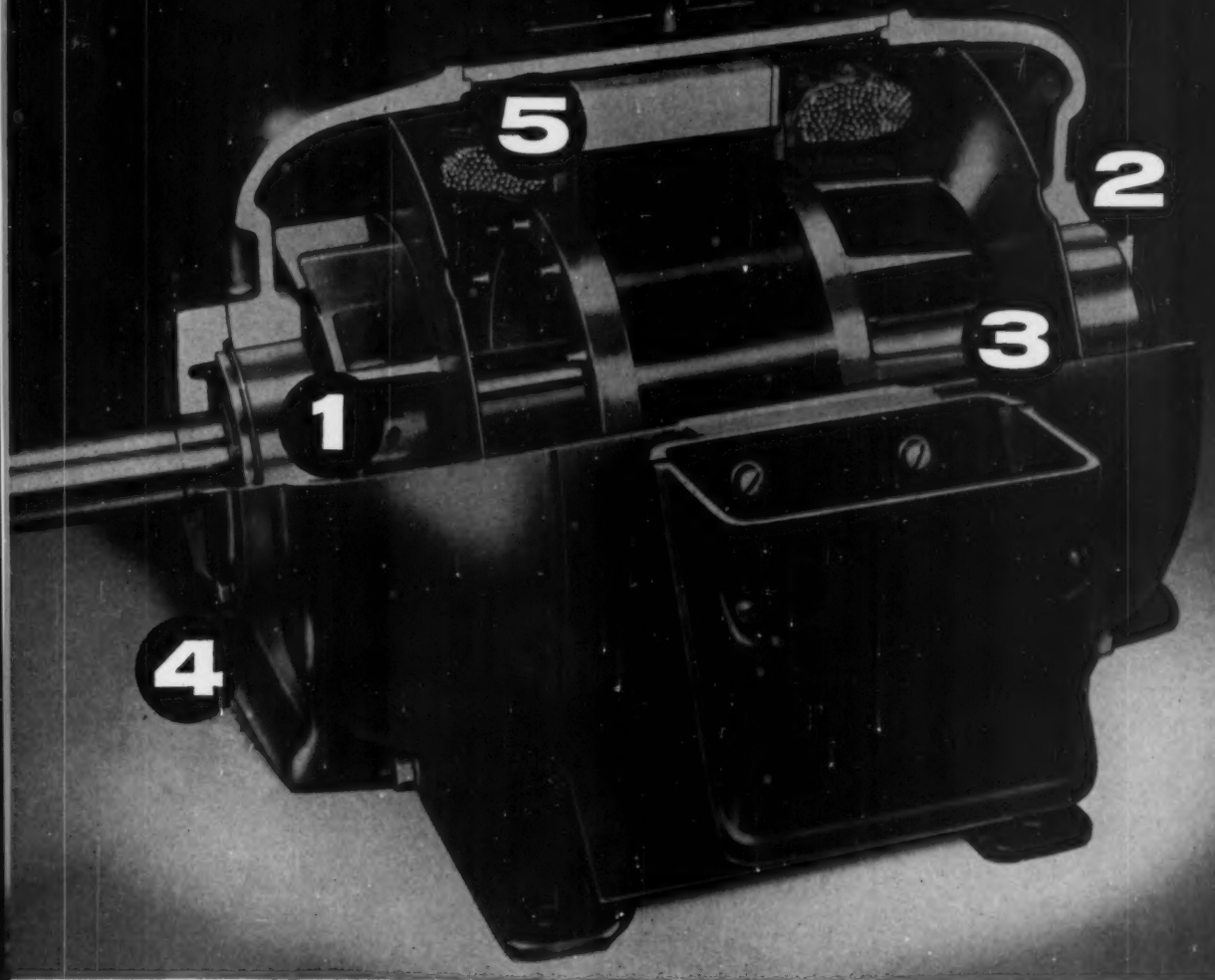
**DuPont registered trademark*

ROBBINS & MYERS, INC., Springfield, Ohio

Fractional and Integral HP Electric Motors • Electric Hoists and Overhead Traveling Cranes • Moyno® Industrial Pumps
Propellair® Industrial Fans • R & M-Hunter Fans and Electric Heat • Trade-Wind Range Hoods and Ventilators
Subsidiary companies at: Memphis, Tenn., Pico Rivera, Calif., Brantford, Ontario.

MOTORS 1 thru 200 HP

(other ratings 1/200 to 1 horsepower)

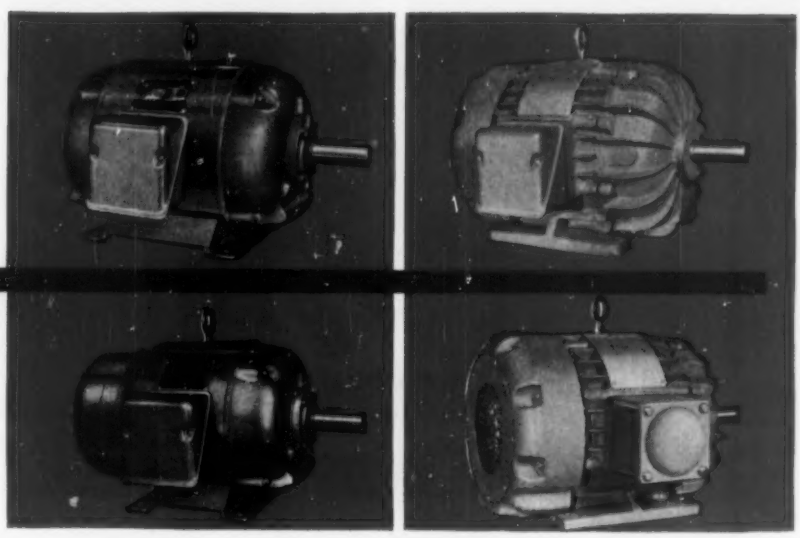


Open Protected Polyphase Motors (left), up to 200 HP, are suitable for many applications formerly requiring totally enclosed construction.

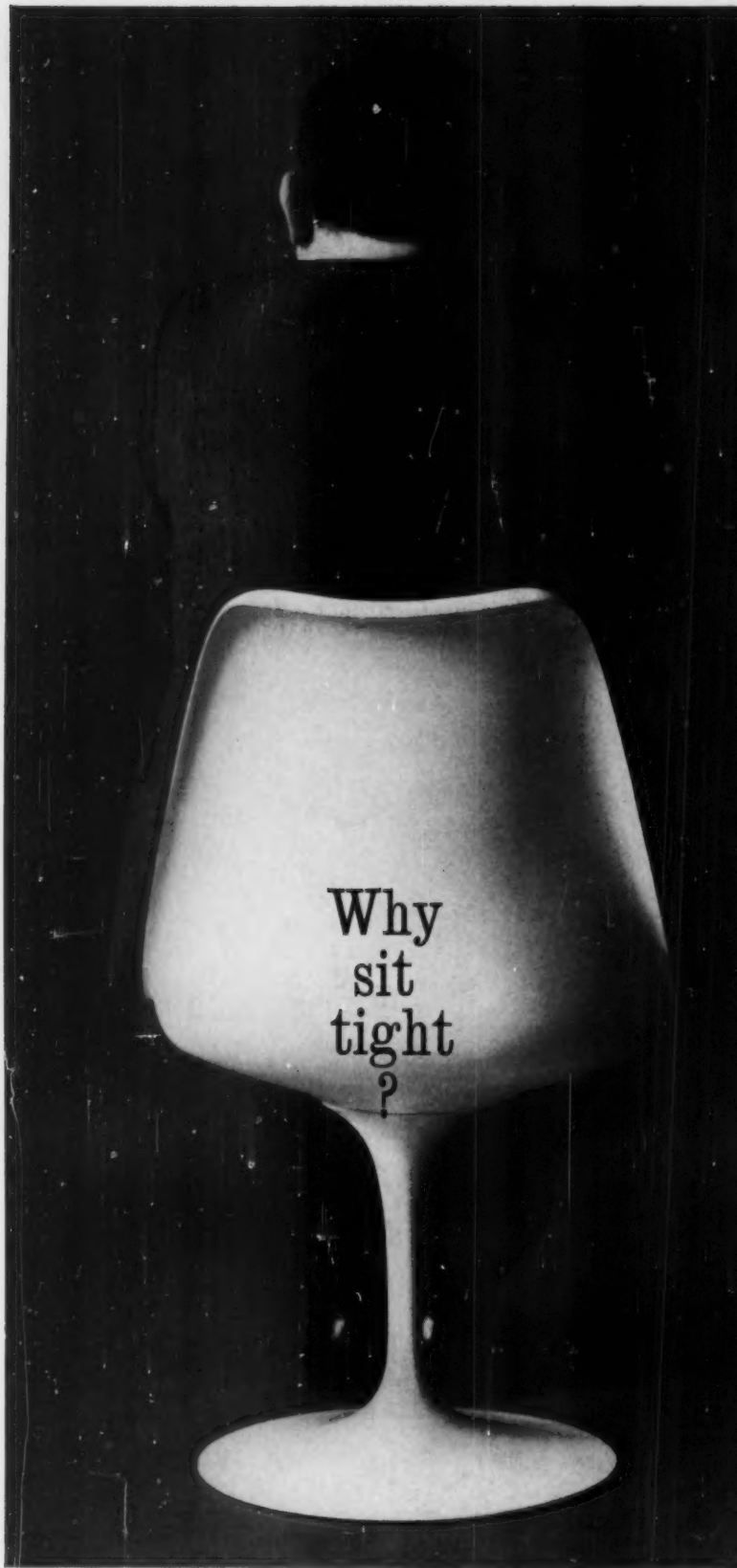
Totally Enclosed Motors (right), ½ to 200 HP, are fan-cooled . . . offer complete protection against all harmful atmospheres.

"PM" Single Phase Motors (left), ratings through 20 HP, eliminate maintenance because they are fully weatherized for severe duty.

Explosion-Proof Motors (right), ratings through 200 HP, are Underwriters' Approved for Class I, Group D, and Class II, Groups F & G.



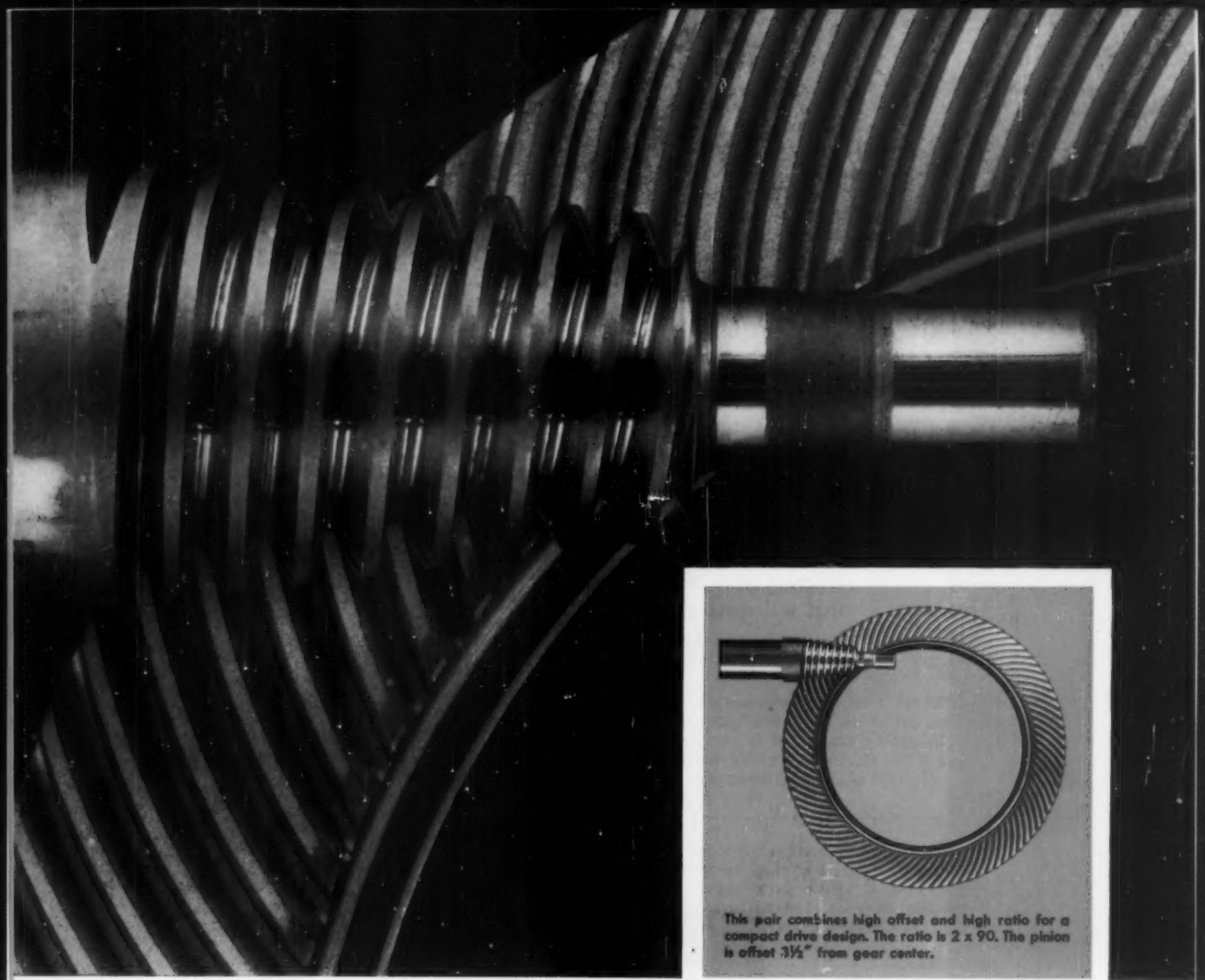
CIRCLE 47 ON READER SERVICE CARD



Put your problem to an old problem-solver: Laminac® Polyester Plastic.

Reinforced Laminac polyester resin has been solving difficult materials problems for 19 years. Reason: Reinforced Laminac offers superior physical and electrical properties. High structural and impact strength. Dimensional stability. Corrosion resistance. Arc resistance. Dielectric strength. Economical, high and low-volume fabrication of unusual shapes, large and small. Low-cost tooling. In one molding operation, reinforced Laminac gives form, strength, color and finish. Put your materials problems to reinforced Laminac—the pioneer polyester. Available in 22 formulations for specific problem-solving.

AMERICAN CYANAMID COMPANY CYANAMID PLASTICS AND RESINS DIVISION
Wallingford, Connecticut. Offices in: Boston • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Detroit • Los Angeles • Minneapolis • New York • Oakland • Philadelphia • St. Louis • Seattle • In Canada: CYANAMID OF CANADA LIMITED, Montreal • Toronto



This pair combines high offset and high ratio for a compact drive design. The ratio is 2 x 90. The pinion is offset 3½" from gear center.

See how the teeth "wrap around" this high-reduction pinion

This is a high-ratio hypoid gear. In principle, it is not different from more conventional hypoids produced by the Gleason Works. *But . . .*

If you look closely at the pinion, you'll notice that the teeth tend to "wrap around" it. This design is extremely well suited for high reduction, strength and compact design.

The result is a conical (or sometimes cylindrical) pinion which permits *continuous tooth action—even with just one or two teeth!* Compared to corresponding bevel pinions, its diameter is greater for higher strength. An extended shank on cylindrical pinions makes *very rigid* straddle mountings practical.

You can design a *compact* unit, because high offset is possible! For high-offset *or* high-ratio pairs, the "wrap around" tooth design provides an extra measure of the smooth, quiet tooth action of hypoid gears.

High-ratio hypoids can be cut on the same Gleason equipment that is used on more familiar spiral bevel gears and hypoids. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish.

High-ratio hypoids can be produced by the Gleason Works for ratios of 1:10 or 1:40 or even higher. They are finding a growing number of applications in such diverse fields as farm machinery, instrumentation and office equipment.

You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

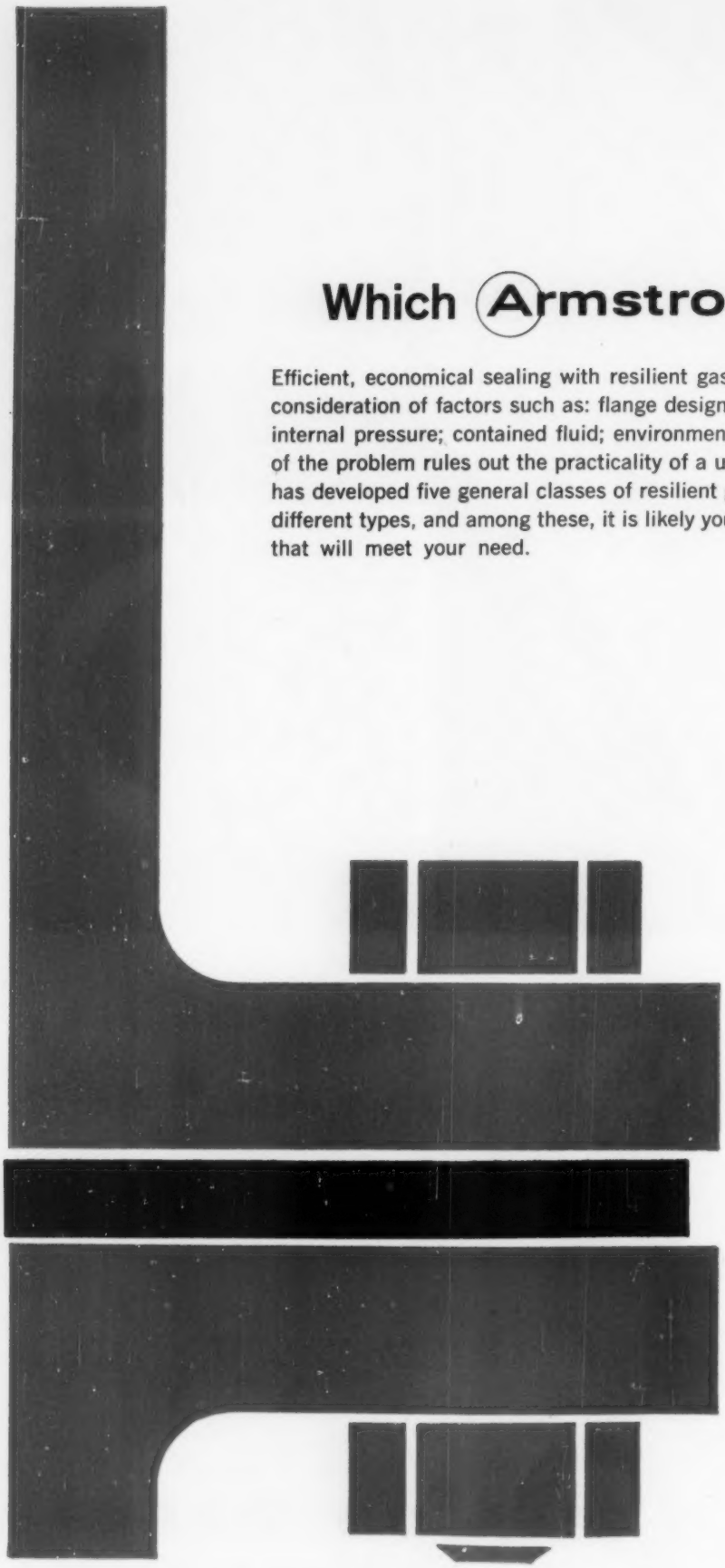
GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

CIRCLE 49 ON READER SERVICE CARD

Which Armstrong resilient gaske

Efficient, economical sealing with resilient gasket materials begins with consideration of factors such as: flange design; flange pressure; temperature; internal pressure; contained fluid; environment; price. Because the complexity of the problem rules out the practicality of a universal material, Armstrong has developed five general classes of resilient gaskets. They include 48 different types, and among these, it is likely you will find one or more that will meet your need.



Accopac—asbestos fiber

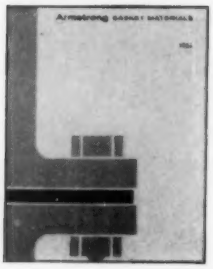
Synthetic rubber

Accopac—cellulose fiber

Cork-and-rubber

Cork compositions

or your job?



Send for new catalog

This new 20-page booklet contains detailed information on the broad line of Armstrong resilient gasket materials.

Refer to it in Sweet's product design file or send for a free personal copy. Write to Armstrong Cork Company, Industrial Division, 7102 Irvin Street, Lancaster, Pennsylvania.

These are beater-saturated combinations of asbestos fiber and nitrile-, styrene-, or chloroprene-type latex binders. Free of undispersed clumps of fibers, they are unusually uniform, tough, flexible, and easy to handle even in 1/64" gauge. Torque retention characteristics and resistance to extrusion are excellent. For this reason, Accopac asbestos materials are widely used in heavy-duty applications at temperature range of cellulose materials (up to 300° F.) as well as in the normal range for asbestos gaskets (300° F. to 800° F.).

These are special formulations based on a variety of standard synthetic polymers, including silicone and fluorocarbon types. They provide a wide range of hardness, elasticity, and tensile strength.
Straight rubber compounds are extensible and non-compressible, suitable for applications where the gasket must be assembled over a projection or where it must flow into threads or recesses. These materials have generally good resistance to solvents, oils, water, heat, oxidation, sunlight. Low compression set.

General-purpose beater-saturated fiber materials. Synthetic latex binders (nitrile-, styrene-, or chloroprene-type rubber) are non-volatile and non-extractable in any recommended application. Accopac materials are dimensionally stable, will not warp, shrink, or dry out.

These materials offer the double economy of long service life and low initial cost.
Six Accopac cellulose materials are available. They accommodate a wide range of unit loads and sealed fluids, at flange temperatures up to 300° F.

These materials provide a transition from the compressibility of cork composition to the non-compressibility of straight rubber. Will compress from 20% to 33% without excessive sideflow, depending on cork content of particular compound. Fifteen Armstrong cork-and-rubber materials are available. These compounds are made with nitrile-, styrene-, chloroprene-, or butyl-type binders. Chemical resistance is comparable to corresponding base polymers. Several types meet MIL-G-6183 and other specifications.

Widely used general-purpose gasket materials. Available with resin or protein binders or a new, continuous phase elastomeric binder (Uniphase Cork). Density varies from 14 to 28 lbs. per cu. ft., and compressibility varies from 5% to 50% at 100 psi depending on composition. (Nine Armstrong compounds available.) Cork compositions are compressible without appreciable sideflow. They have excellent resistance to oil and solvents and have high friction whether dry or wet. The Uniphase compounds are virtually fungusproof.

Armstrong GASKET MATERIALS

HYDRECO
out front in . . .
RESEARCH and TEST FACILITIES

. . . JUST ONE MORE WAY HYDRECO SERVES YOU BETTER! Yes, these testing facilities are typical of the most modern precision equipment used in our experimental laboratory. They permit life testing and calibration of hydraulic pumps, motors and valves far beyond that required by most mobile and industrial equipment in use today.

With the aid of equipment like this, new designs, new techniques, new concepts of hydraulic application are being constantly created at Hydreco. No wonder Hydreco engineers are maintaining performance and reliability standards unsurpassed in the field of hydraulic components.

If you build construction equipment or machines for agriculture and industry, keep these unique facilities in mind. *Remember, it's one more way Hydreco serves you better!*

HYDRECO® DIVISION
THE NEW YORK AIR BRAKE COMPANY
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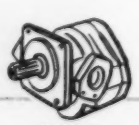
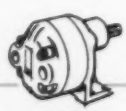
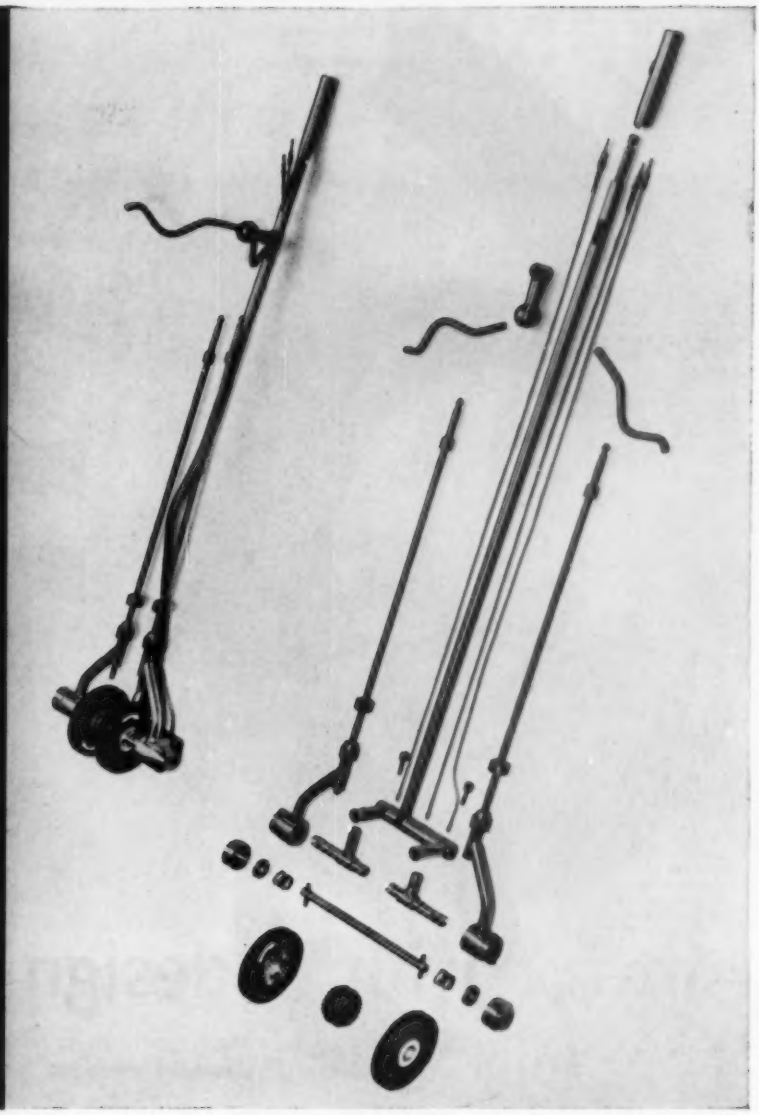

PUMPS

VALVES


MOTORS

HERE'S HOW STILL ANOTHER MANUFACTURER JOINS STAINLESS STEEL TUBING:

He uses Handy & Harman's BRAZE 630



He's one of many manufacturers and fabricators who have found—to their lasting satisfaction—that Handy & Harman silver alloy brazing is the final answer to stainless steel joining problems.

Super-Donic Manufacturing Company, Atlanta, Georgia, manufactures "Dual Arm Transmissions" for the dental industry. Most everybody has—at one time or another—seen and/or felt this unit in operation.

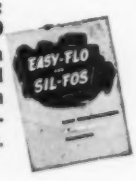
It is fabricated of small diameter 304 and 316 stainless steel tubing and, in its assembled form, consists of some 17 separate brazed joints. Joints must be strong, corrosion resistant and neat-appearing.

Each of the 17 joints is hand-torch brazed with Handy & Harman BRAZE 630 wire and HANDY FLUX TYPE B-1. There's no question that this is a unique application. There's no question, either, that the application is stainless steel. The ease and economy with which this manufacturer solves his problems can be just as readily applied to *your* stainless steel joining problems.

Strength, production speed, electrical and thermal conductivity, gas and liquid tightness and low cost are *natural* benefits of silver alloy brazing. We think it worth your while to learn more about this remarkable metal-joining method—we'll be glad to send you any information you ask for. Handy & Harman, 82 Fulton St., New York 38, N. Y.

FOR A GOOD START:
BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits... includes details on alloys, heating methods, joint design and production techniques. Write for your copy.



Your No. 1 Source of Supply and Authority on Brazing Alloys

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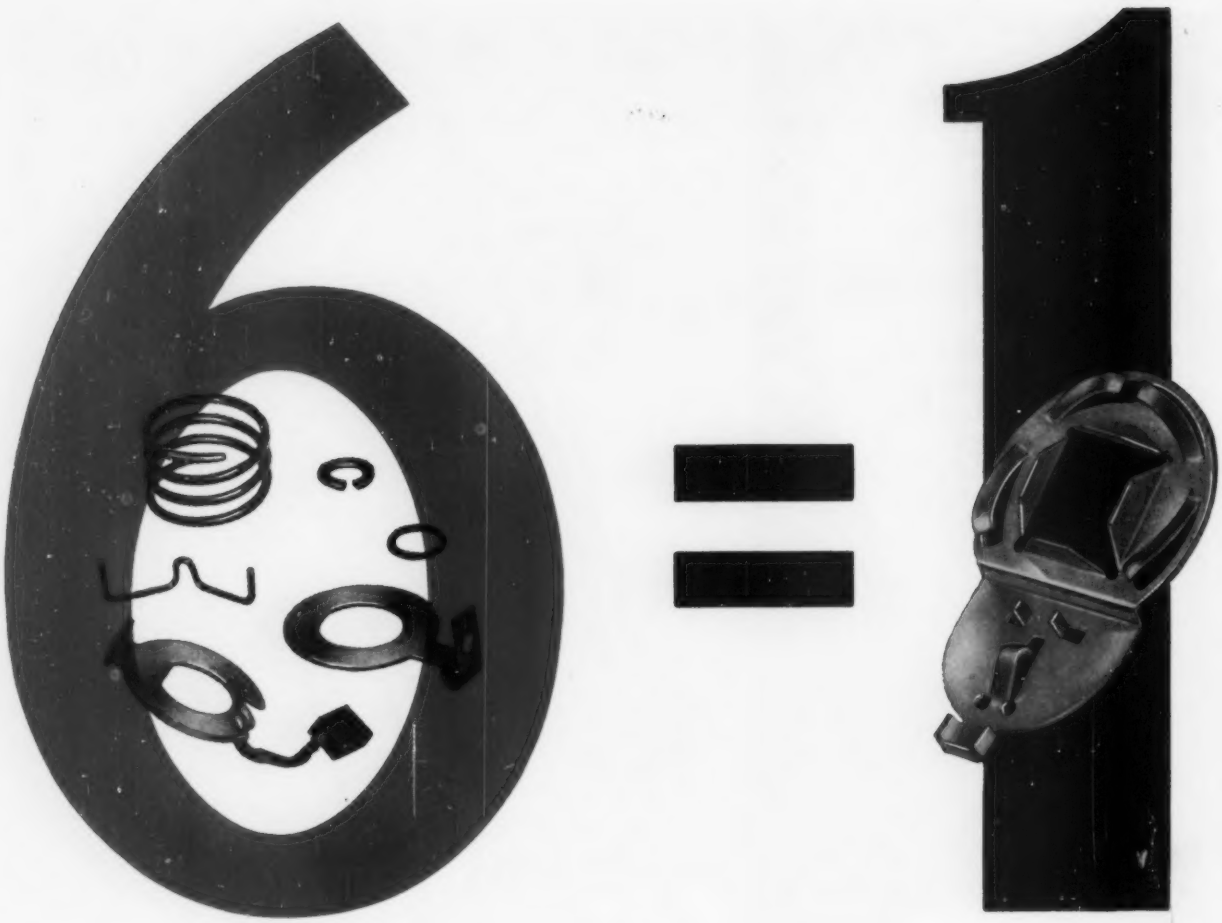

with re-design 'rithmetic

One flat spring now does the work previously required of the six parts shown—and greatly simplifies assembly, too. This single multi-purpose spring (a) holds a carbon brush in a rheostat, (b) applies pressure on the wire windings, (c) provides friction detent action, (d) acts as a retainer on the rotating shaft.

How did this come about? The maker of the rheostat undertook a complete redesign analysis, called in an A.S.C. Spring Engineer when it concerned the spring.

Early consultation with A.S.C. springmakers in new or redesign projects gives greater range to plans, safeguards against high production costs. Our booklet, "Designing Springs for Performance," may help you. Write for your copy.

8902

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
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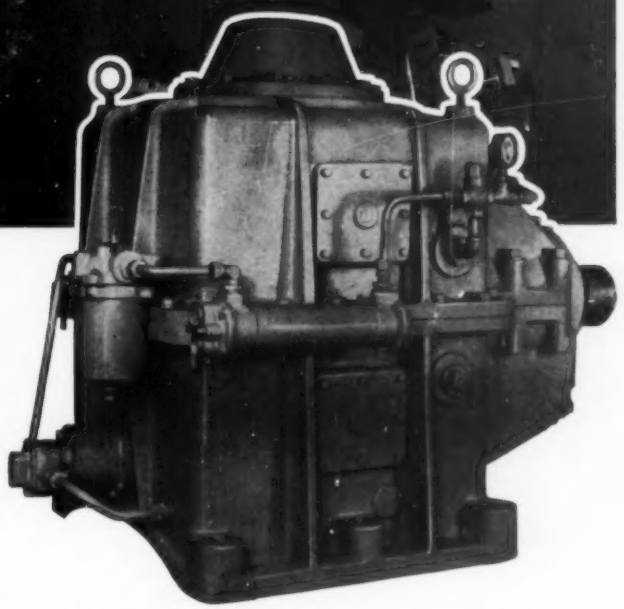
PHILADELPHIA REDUCERS
keep disaster from Hartford

Five miles of dikes protect Hartford, Connecticut against river heights of 45 ft. Yet excess drainage into low lying industrial areas starts at 8-foot levels. Result: pumps operate almost continuously . . . 7 days a week! Seven flood control pumps for Hartford . . . totalling 224,000 gpm . . . are all driven through 450 hp, 1200 rpm Philadelphia Spiral Bevel Reducers.

There are three good reasons why Philadelphia Spiral Bevel Reducers give extra reliability on any continuous, heavy duty job.

1. Spiral bevel gearing is heat treated and hardened after it is cut . . . then lapped to a mirror finish for perfect tooth contact.
2. Heavy-duty bearings and generous bearing spans provide extra rigid mounting and keep bearing loads low.
3. Force feed lubrication. Generous oil reservoir and large radiation surfaces mean cooler running units.

Catalog SB-60 describes our complete line. Write for your copy today.



Philadelphia Spiral Bevel Reducers offer dependable performance with high efficiencies. Housings are fully enclosed, compact and self contained with freedom from oil leakage. Note easy accessibility of oil pump, filter, and cooler.

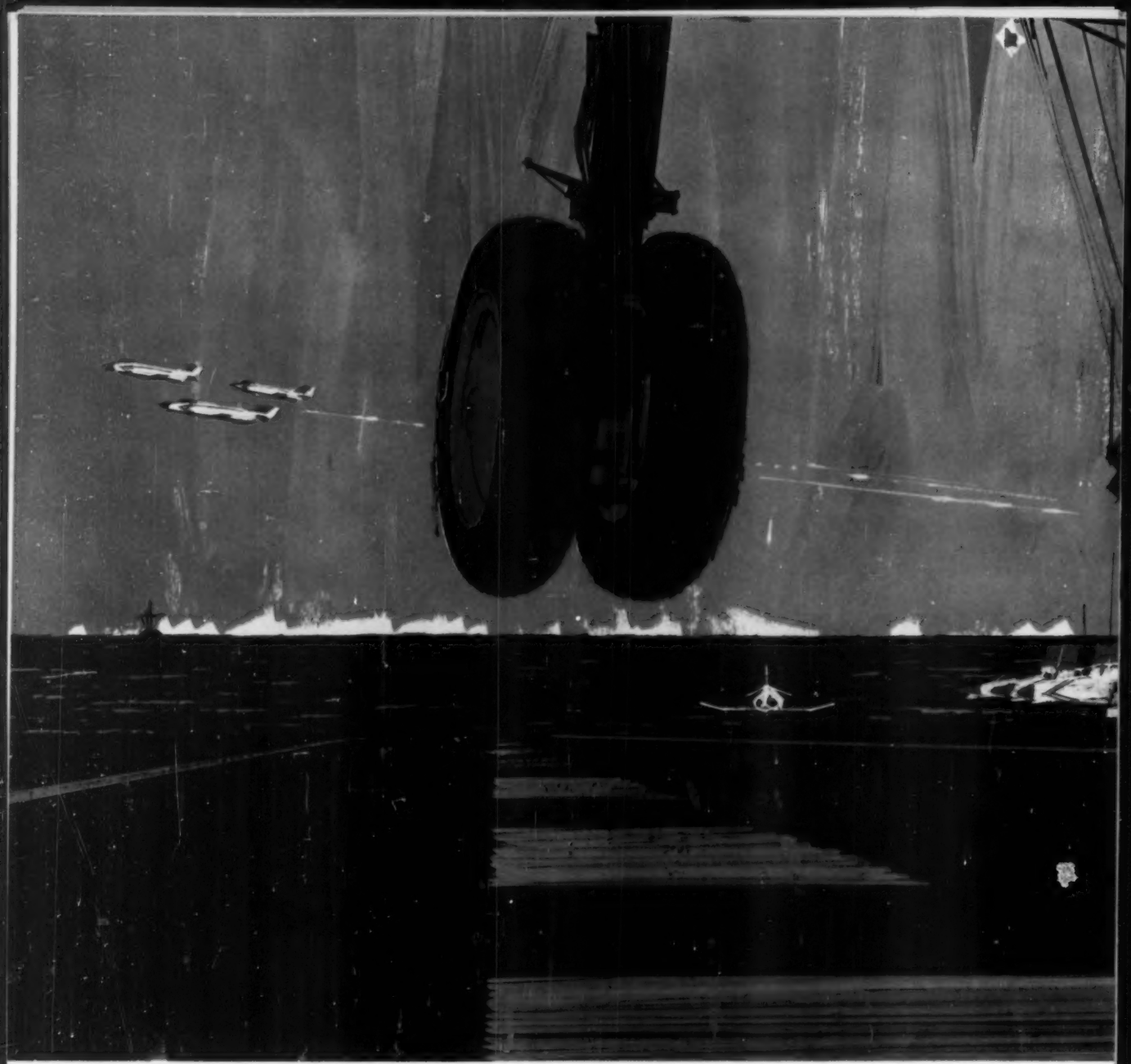
philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

King of Prussia (Suburban Philadelphia), Pennsylvania

CIRCLE 55 ON READER SERVICE CARD

CIRCLE 56 ON READER SERVICE CARD→



NS SPECIAL WIRE WITHSTANDS 1000°F

Landing hot jets like the McDonnell Phantom II at high speeds, means brakes and brake components must be able to withstand extreme temperatures without failure.

A leading manufacturer of brakes for jet aircraft came to National-Standard for help in finding a spring wire that would have high stress-temperature stability up to 1000°F. National-Standard engineers recommended an austenitic superalloy material, NS-A286, recently developed for spring wire applications by National-Standard. Tests showed that NS-A286 met requirements better than any other available alloy, yet cost only half as much as the next best alloy.

SUPERALLOY PASSES TEST—When brakes on the Phantom II are released, the NS-A286 return springs under the brake discs must separate the stationary stator discs from the moving rotor discs. The brake discs build up heat to 1400°F, which is quickly absorbed by the return springs, raising spring temperatures to as much as 1000°F. NS-A286 is a precipitation hardening alloy exhibiting as little as half the relaxation loss at 1000°F as comparable alloys show at 850°F. NS-A286 springs must retain their strength at this heat to separate the brake discs and guard against brake drag during landings.

To test NS-A286, engineers simulated stress-temperature characteristics of three landing conditions.

TO BRAKE JETS

Heat builds up in the brakes in 30 seconds and remains for as long as 20 minutes. The springs must work in the heat against a high back pressure maintained in the aircraft hydraulic system. Springs must be operational for at least 45 normal landings, 5 high-speed, gross weight landings, and one aborted take-off stop, corresponding to stopping the plane just before it becomes airborne. Under all test conditions, NS-A286 met every rigid requirement.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.

NS-A286 SUPERALLOY WIRE, produced by National-Standard, meets critical stress-temperature demands for coaxial return springs in brakes of F4H-1 Phantom II.

Manufacturer of Specialty Wire and Metal Products

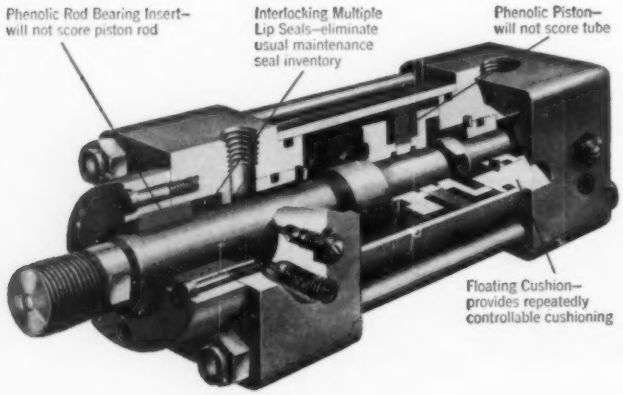
NATIONAL-STANDARD COMPANY

Niles, Michigan

Fluid Circuitry News from Westinghouse

Industrial Product Division expands line

The Petch line of high quality air and hydraulic cylinders is now part of the line of Westinghouse Fluid Circuitry components. This acquisition makes it possible for us to offer industry the *most complete line* of air and hydraulic components for control systems to automate industrial production operations.


Phenolic Rod Bearing Insert–will not score piston rod
Interlocking Multiple Lip Seals–eliminate usual maintenance seal inventory
Phenolic Piston–will not score tube
Floating Cushion–provides repeatedly controllable cushioning

The Petch line of rugged, precision made cylinders include the following models:

Air & Low Pressure Hydraulic Cylinders

150 psi Air 500 psi Hydraulic
1″ to 10″ Bores
10 Standard Mountings

High Pressure Hydraulic Cylinders

1½″ to 6″ bores—2000 psi
8″ to 10″ bores—3000 psi
10 Standard Mountings

All Petch Cylinders conform to J. I. C. Standards.

FLUID CIRCUITRY... FOR TROUBLE-FREE AUTOMATION

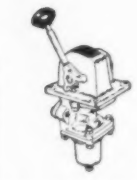
Fluid Circuitry is the application of fluid control systems to industrial production operations.

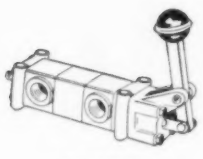
Fluid Circuits are economical, safe and precise. They are used to solve the most vigorous and complex control problems.

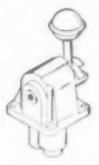
They contain reliable products to boost your production and cut your production costs.

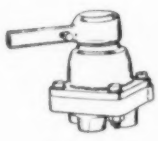
For more information on Petch Cylinders and Fluid Circuitry ask for catalog A3-56.00.

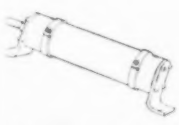
See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

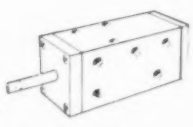

Pressure Control Valves


Spool Type Directional Valves

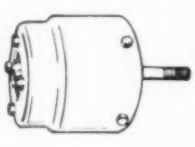

Poppet Type Directional Valves

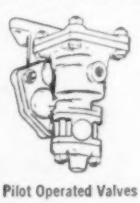

Rotary Type Directional Valves


Clamp Ring Cylinders

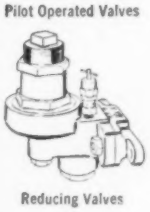

Multi-Position Cylinders

Infinite Position Actuators

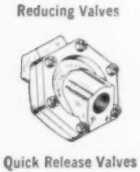

Diaphragm Cylinders


Pilot Operated Valves

Relay Valves


Reducing Valves

Cut Out Cocks


Quick Release Valves

Flow Control Valves

Air Line Conditioners

Filters & Strainers

WESTINGHOUSE AIR BRAKE COMPANY
INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

DIAMOND

cracks DESIGN BARRIERS

New horsepower ratings* for DIAMOND Roller Chains, plus four new products, have opened up a whole new range of DIAMOND Roller Chain applications for design engineers!

Size for size, DIAMOND now gives you increased horsepower capacity, higher speeds, longer life, and greater economy in present applications . . . and suggests many new areas in which roller chain efficiency can be utilized.

Example: *Former* ratings for 1″ pitch roller chains permitted sprocket speeds up to 1160 RPM; *new* ratings include speeds to 2800 RPM. Rated horsepower capacities formerly did not exceed 49 HP; *new* ratings exceed 150 HP.*

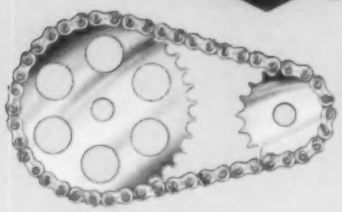
*New speed and horsepower ratings are those established by the Association of Roller and Silent Chain manufacturers, of which DIAMOND is a charter member.

See next page for DIAMOND's four new product developments which may help you solve present special problems.

Available now—new DIAMOND Stock Roller Chain, Sprocket and Coupling Catalog No. 760 with new higher ratings for roller chains.

DIAMOND CHAIN COMPANY, INC.
A Subsidiary of American Steel Foundries
402 Kentucky Avenue · Indianapolis 7, Indiana

DIAMOND *Micropitch*® ROLLER CHAIN



World's smallest bushing type chain!

Actual Size
.1475" PITCH
.035 Lb./Ft.
Tensile Strength: 180 Lbs.

For cameras, computers, recorders and other devices with miniaturized movements requiring strength, synchronization, and precision. Precision built of corrosion resistant, non-magnetic stainless steel. Stock sprockets available . . . or made to your specifications. Conveyor chain supplied with special attachments on custom orders.

For additional information, request free Bulletin

® REGISTERED IN UNITED STATES PATENT OFFICE

These new products can help solve your design problems

DIAMOND *hi-Cap*™ FLEXIBLE COUPLINGS

Shaft-rated for selection by shaft diameters!

Hi-Cap Couplings give you

- Lower Cost
- Bearing and Shaft Protection
- High Torque Capacity

Hi-Cap means High Capacity

All working parts are heat treated steel, hardened to give greater resistance to wear and longer service life. Hi-Cap Couplings can be quickly installed, aligned and connected without special tools. A single pin easily connects the coupling chain. Removal of chain completely disengages the driving and driven units. Available in Finished Bore and Taper Lock.

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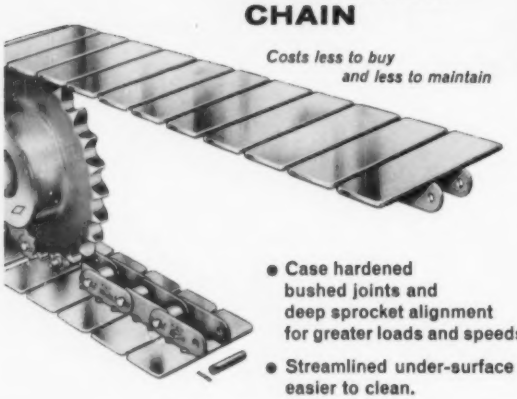
The trademark *Hi-Cap* is the property of Diamond Chain Company, Inc.

DIAMOND *duraweld*

TOP PLATE

CONVEYOR CHAIN



Costs less to buy and less to maintain

- Case hardened bushed joints and deep sprocket alignment for greater loads and speeds
- Streamlined under-surface is easier to clean.

DIAMOND "Projection welds" produce a permanent metal fusion as strong as the metal itself. *Duraweld* eliminates rivets, attachments and extra fittings. *Duraweld* is easily detachable at any joint. Links are interchangeable with links of other roller chains of the same general type and may be used on existing rails.

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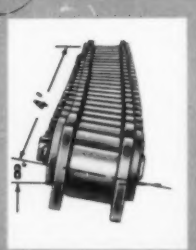
DIAMOND TUF-FLEX™

ROLLER CHAIN

Rugged new *straight link* transmission chain meets severe demands of power shovels, transit-mix trucks, and other heavy equipment.



Extra clearance between inside and outside linkplates and between pins and bushings permit extra flexibility and reduces stiffness.

Each 4' of TUF-FLEX Chain provides up to 4" lateral displacement from center line and up to 8° twist to accommodate sprocket misalignment.

Proven advantages: Longer service life, greater capacity for shock and peak loads. Easier chain connection; may be used over existing sprockets cut for American standard roller chains of same pitch, or equivalent offset side bar chains.

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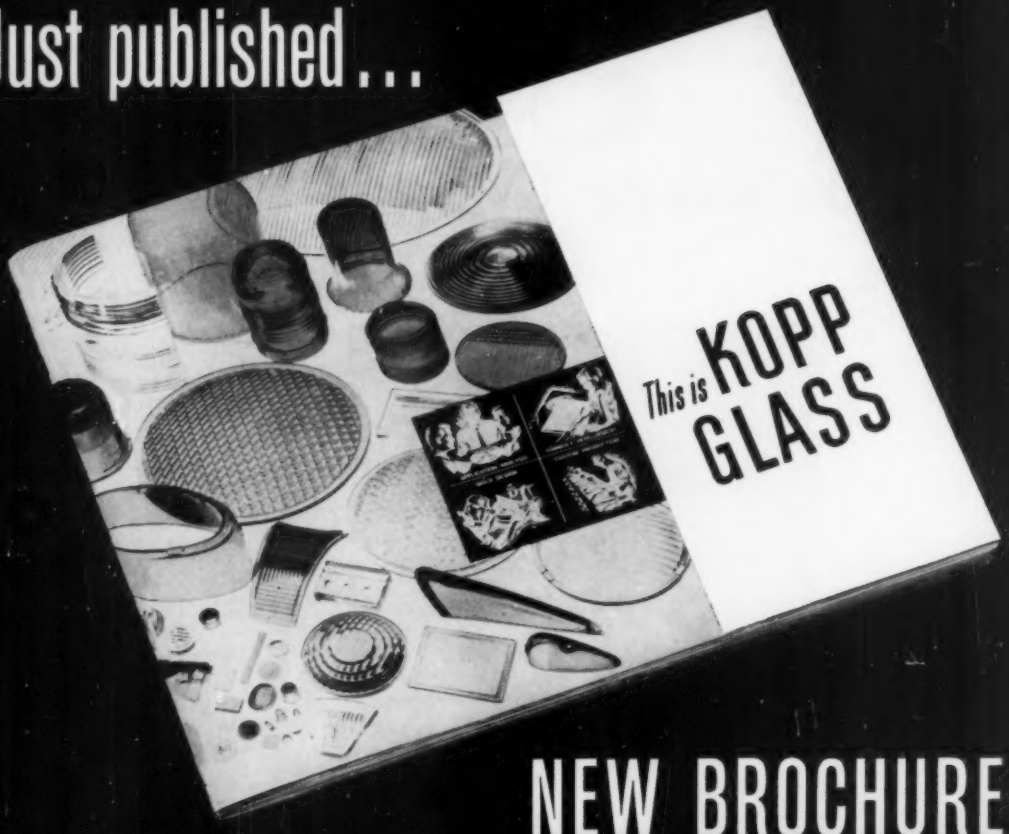

NEW BROCHURE

shows how Glass can be engineered to solve specific design problems

Twenty colorful pages describe the Kopp Glass engineering service; showing how the properties of glass are controlled and combined to provide designers and manufacturers with specialized, custom-produced products that meet specific application requirements. This includes analyzing the application, developing the formula, designing the mold and establishing manufacturing procedures.

A few examples shown include street and highway traffic control lenses; aviation, marine and railroad signaling lenses; dental and surgical lighting filters; street and interior lighting glassware; floodlight cover glasses; industrial globes and indicator lenses; theatrical and exterior lighting color filters.

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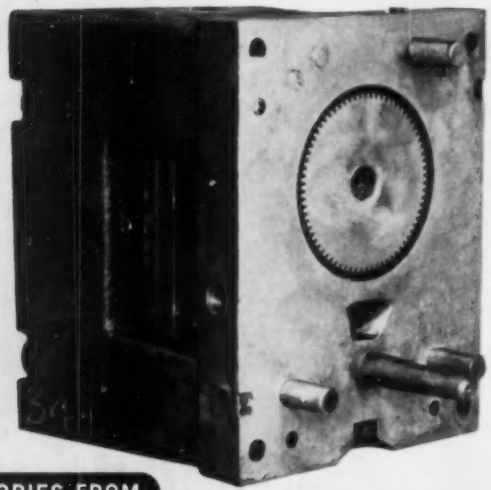
Kopp Glass, INC.
Swissvale, Pennsylvania

MANUFACTURERS OF MOLDED INDUSTRIAL AND SIGNAL GLASSWARE

48 years ago Mt. Vernon created this 'movie star'



CASE HISTORIES FROM MT. VERNON FILES

. . . and here's why the original die is still performing

Back in 1912 in the days of the nickelodeon when the movie industry was in its infancy, the people who made Simplex theater equipment needed a quality die-casting job. They turned to Mt. Vernon for a die that would turn out the gear end for a hand operated film rewinder.

That was Mt. Vernon's 34th die. Yet even today, 48 years later, the original die continues to turn out these same gears *without a single change*. The movie industry still uses Simplex Film Rewinders, and Cinesound Service Corporation of New York who are the current manufacturers still rely on Mt. Vernon to produce the castings.

The fact is that Mt. Vernon's original die proved itself in actual use . . . despite all the myriad changes in die-casting techniques and machines since 1912. For our dies are built to give *continuing* top performance . . . backed by the stability and reliability of a firm that is already in its second half-century.

When you are in the market for die castings think first of Mt. Vernon. We have the abilities to make long lasting dies . . . we have the stability and reliability that insure dependable service . . . not for only a year, or ten years, but for 48 years and more if need be. Contact any of our Field Salesmen. They're eager to help you also make a 'Star'.

MT. VERNON DIE CASTING CORPORATION
STAMFORD, CONNECTICUT

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PRODUCT ENGINEERING HORIZONS

FEBRUARY 20, 1961

Is your morality showing?

Morality, in the troubled times of the Reformation, the Puritans, and even of the Mormons in our own country, was a public concept of private conduct. We still have self-appointed keepers of public morals —book burners, movie censors, local and clerical committees—to say nothing of statutes and ordinances expressing moral rather than criminal laws. Their real worth, their purpose and their very right to existence can be argued, because many such groups and acts represent the will of a more-or-less bigoted minority imposed on a less-vocal, less-cohesive majority.

Morality, which is essentially a private attribute, has thus become a public and rubbery concept. What is moral and what is immoral depends on the times, but not to any perceptible extent on the individual. He has yielded his right to determine his own morality to various bodies which determine it for him—or even on occasion keep it purposely indeterminate.

Take our income-tax laws as a case in point. It is difficult, and usually impossible, to get either concrete advice or rulings on income-tax matters from the IRS. The individual is advised to claim the deduction and see if he can get away with it. The inevitable result is confusion and chicanery.

Carry it further. It is illegal to gamble, but practically everybody does it. The checkrein is not the gambling laws, but the income-tax law, which imposes severe penalties if one fails to report "ill-gotten" gains, whether from horse-racing, bingo, or stock manipulations.

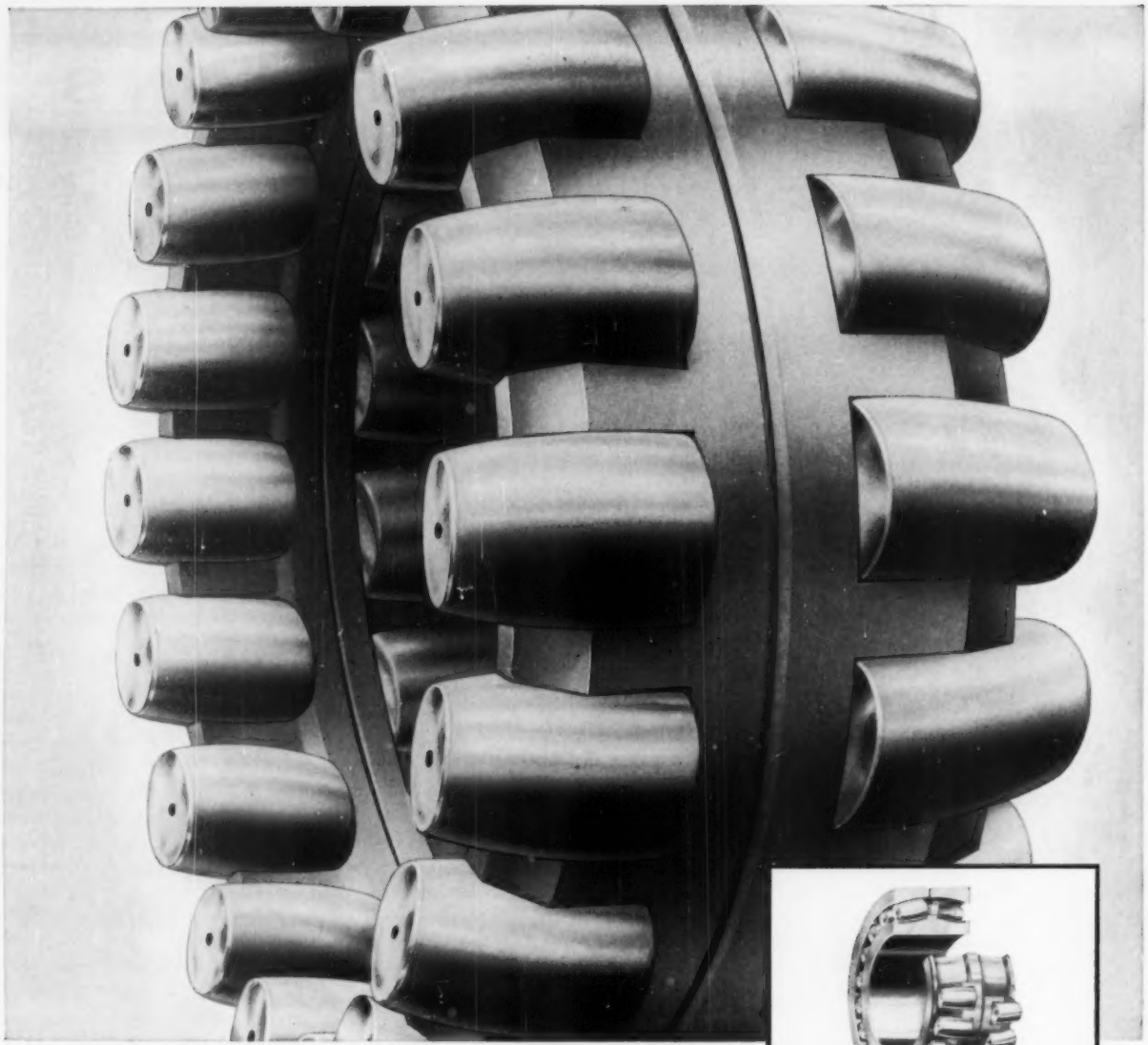
Or consider such mundane regulations as those on speeding and illegal parking. One of our greatest outdoor sports is to violate both; the sin is not the violation, but being caught. And the penalties, in most cases, are so nominal they are no deterrent. Nobody considers a ticket the evidence of law-breaking any more—partly because the laws are so unrealistic. Again, as in income-tax law interpretation, the tendency is to set an abnormally low speed limit or place ridiculous parking meters, then penalize only if violations are major.

Carry the idea still further—into expense accounts that have become "swindle sheets," into food products and drugs that are only "slightly harmful," into get-rich-quick schemes that mulct the innocent and näive, into "self-help" programs that help nobody. All these exemplify the crumbling of private morality even as our public morality is seemingly growing—if records of church attendance, the number of laws and number of investigating committees mean anything.

Is it possible that such doctrines as planned obsolescence grow out of this same attitude? There are those who argue that the inferior product that apes the superior one at a lower price is justified by that lower price, that the product that wears out or breaks in a limited time is essential to our economy of plenty, that the Golden Rule for success is to do others before they do you.

But the whole flimsy structure breaks down when a professional man takes an appraising look at himself. He feels good, really good, about violating a natural "law" and thus discovering it isn't a law at all, for he has thus contributed to the world's knowledge. But he feels decidedly unprofessional when he breaks civil law—written or unwritten—to cheapen what he is doing or to attain some personal or commercial advantage.

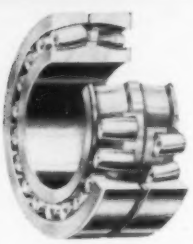
The moral, if there is one: **Morality should be in the hearts of people, not in statutes.**



"Caged" for Longer Life!

The two land-riding cages in Torrington Spherical Roller Bearings assure proper roller spacing and guidance, even under rugged conditions of shock load and sustained high speeds. These fully machined cast bronze cages operate independently. Their design eliminates drag on rollers. These high-strength cages help bearings give longer life by providing low friction, smooth running and cool operation. Highly effective and generous lubrication of all contact surfaces is achieved with the open-end cage design.

The result: Torrington Spherical Roller Bearings are built to give extra years of unmatched service life in heavy-duty applications. Torrington's long experience in design, engineering and manufacture of every basic type of anti-friction bearing provides the finest spherical roller bearings available. You'll find it pays to standardize on Torrington.



Superior design features of TORRINGTON SPHERICAL ROLLER BEARINGS

- integral guide flange for roller stability
- asymmetrical rollers seek flange for positive guidance
- electronically matched rollers
- size-stabilized races
- fully machined land-riding bronze cages
- controlled internal clearances
- even load distribution
- inherent self-alignment
- long service life

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

PRODUCT ENGINEERING

FLEXIBLE METAL TAPES

for high-speed mechanisms

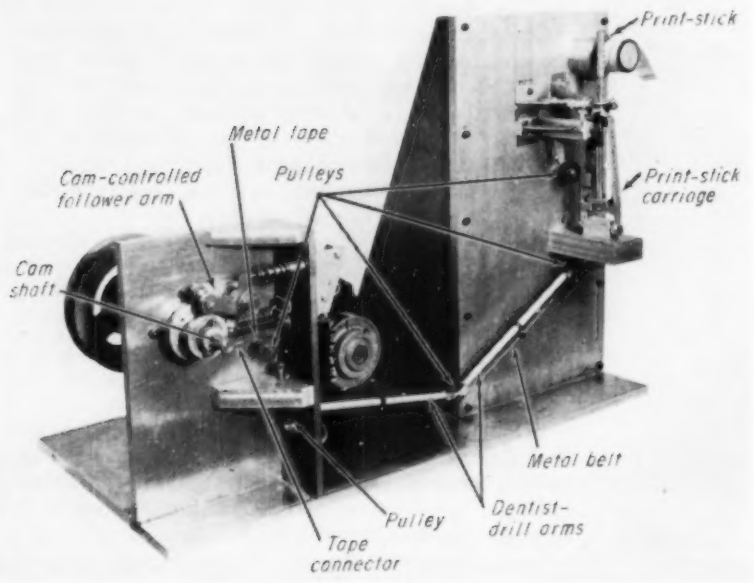
For operating precision mechanisms from a remote source, these metal tapes offer high strength-weight ratio, good fatigue properties. Here are design curves for tapes made of a new steel alloy; two sample problems show how to apply the data.

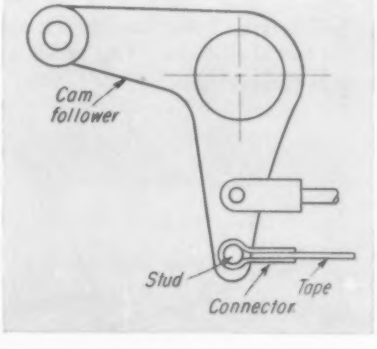
CHARLES B HEBELER
Development engineer
Burroughs Laboratories, Burroughs Corp
Paoli, Penna

A frequent problem in the design of precision mechanisms is to find an accurate means of transferring motion between remote linkage elements. Nonmetal belts stretch too much for such purposes, and a series of linkages creates dynamic problems at higher speeds. What is needed is a low-weight transfer element with high-strength and fatigue-resistant qualities. The answer may well be the use of flexible metal tapes.

We recently found that tape extremely useful, in a cam-driven printer, for operating, and precisely controlling, the reciprocating movement of a lightweight print-stick. A model of the unit, constructed to check out feasibility of the metal-belt system, is illustrated in Fig 1. The power source is a cam-controlled oscillating follower arm at the left end of the unit. The print-stick is at the right end. Its reciprocating motion must be precisely synchronized with the cam shaft. The connecting element, capable of transmitting load in addition to motion, is a flexible metal tape, guided by five pulleys mounted on movable tubular "dentist-drill" arms. (On this feasibility model, the print-stick is restricted to printing in one column only. Multi-column printing can be obtained by having the print-stick carriage move along the stationary paper.)

Besides their high strength-to-weight properties and pre-





1. . METAL TAPE (left) conveys reciprocating motion from cam follower to print-stick by means of five pulleys. The tape is made of thin (0.003 in.) metal strip. Detail of follower is shown above.

REPRINTED—Circle 586, inside back cover

HAVAR STEEL FOR METAL TAPES

A new steel alloy applied successfully to flexible tapes is Havar, manufactured in strip form by the Hamilton Watch Co. It is characterized principally by its high fatigue resistance and high tensile strength. This nonmagnetic alloy is age-hardenable under controlled conditions. It has good corrosion resistance and is finding applications as a new spring material. Havar can be obtained in a thickness range of 0.0001 to 0.050 in. Widths may vary from 0.040 to 3 in.

Havar strip is available in two conditions—the "as-rolled" and the "aged" (see table). The as-rolled is superior in flexure and can be bent back on itself without breaking. Aged tape, when subjected to such treatment, will break with a snap—but it has a higher tensile strength and will outperform as-rolled strip when running over pulleys of ½ in. dia or larger. Also, aged strip seems to track better on the crown of a pulley, a phenomenon believed to occur because of a slightly higher modulus of elasticity. To minimize edge-cracking tendencies, the edges of the strip should be deburred (and rounded to some extent) at the mill.

PROPERTIES AND CONSTANTS OF HAVAR TAPE

NOMINAL COMPOSITION, %:

Cobalt	42.5	Carbon	0.20
Nickel	13.0	Beryllium	0.04
Chromium	20.0	Manganese	1.60
Molybdenum	2.0	Tungsten	2.80
Iron	Balance		

PHYSICAL PROPERTIES:

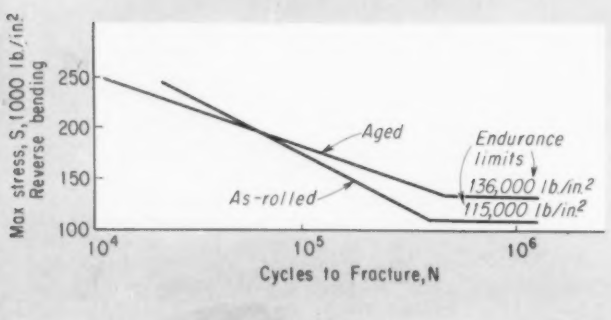
	As Rolled	Aged
Tensile Strength, psi	260,000–290,000	330,000–360,000
Yield Strength, psi (0.02% set)	200,000–220,000	260,000–280,000
Rockwell Hardness (C)	48–50	56–60

PHYSICAL CONSTANTS:

Specific gravity, g/cc	8.3
Density, lb/in.^{3}	0.300
Coefficient linear expansion, in./in./°c (0 to 50 °C)	0.000,012,5
Electrical resistance, ohms/cir. mil ft	550
Thermoelasticity, °C (0 to 65 °C)	51 X 10^{-6}
Modulus of elasticity, psi (x 10^6)	29.5 to 30.2

dictable life-load characteristics, metal tapes can take large angles of twist. One tape has been successfully operated while twisted 180° over a 2-in. span—no need for a series of linkages to change the plane of motion. Also, the tape can be operated skewed at a small angle from a pulley, the only apparent limitation being that the pulley flange must not be of such contour as to wear the belt unduly.

Flexible tapes, being tension elements, should be spring-loaded taut at all times. This makes it awkward to employ them as endless tapes.



2 . . S-N FATIGUE CURVES for Havar strip in "aged" and "as-rolled" condition. Materials for metal tape must have high fatigue-resistant qualities because of continual flexing.

Belt stresses and loads

The three key parameters in metal-tape design are tape width, thickness, and pulley diameter. For a given tape width and pulley diameter, the thicker the tape, the higher the bending stress in the belt going around the pulley. This bending stress, when subtracted from the maximum allowable, yields the useful tension (work) load that can be applied to the tape.

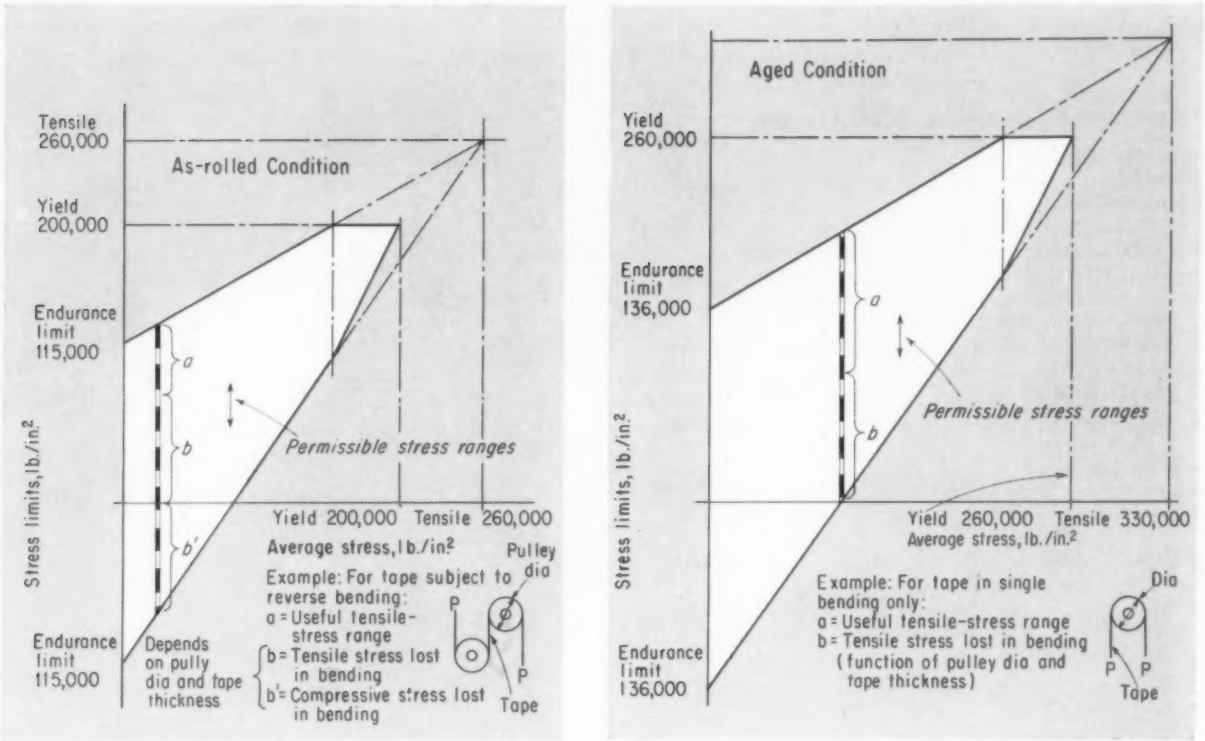
Conversely, a thin tape will be subject to less bending stress in rounding a given pulley, but its smaller cross-section permits only a limited tape load to start with.

Thus, there is a best tape thickness for each pulley diameter. Design charts have been developed for the purpose. Also to be considered is whether a surface element on the tape is subjected to reverse bending or single bending in addition to tensile loading.

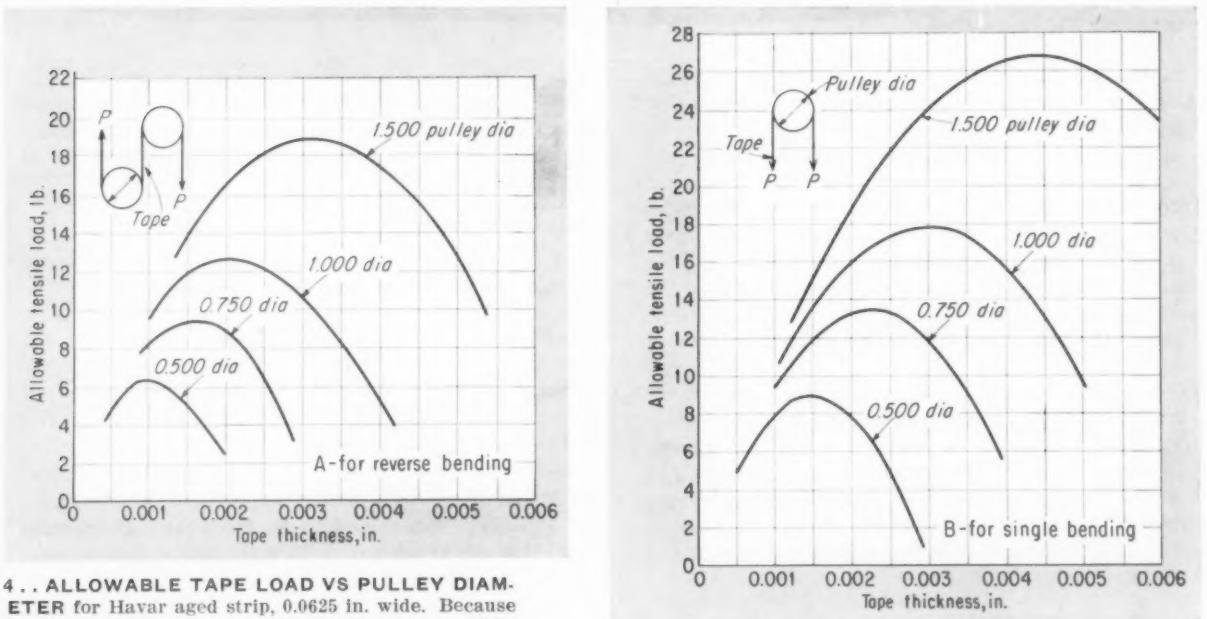
Tests were conducted to determine the endurance limit of tape made of Havar metal strip (see next page). This stress value enables a plot to be made of the useful tape load as a function of thickness, pulley diameter, and type of loading for indefinitely large cycle life.

The endurance limit

Because the metal tape is continually flexed around its pulleys, either in single or reverse bending, the main limiting factor is its endurance limit. When a body containing a region of stress concentration is loaded, the material may flow locally without failure. If the load is reversed, the plastic flow is likewise reversed, and with



3 . . **ALLOWABLE STRESS RANGES** for tapes made of Havar strip.



4 . . **ALLOWABLE TAPE LOAD VS PULLEY DIAMETER** for Havar aged strip, 0.0625 in. wide. Because load is proportional to width, load for other widths can be calculated from these curves.

many repetitions of this cycle, a crack may develop in the flowing material. This crack tends to progress, or propagate, by the same action that originated it, and eventually the material may fail in fatigue. Fatigue cracks originate at obvious surface notches and defects, but may also start at local weaknesses in the microstructure. Note also that fatigue failure may occur at reversed stresses considerably below the elastic limit as determined in an ordinary static test.

When fatigue-testing the Havar strip, alternating stresses

SAMPLE DESIGN PROBLEMS

1—Reverse Bending

A metal tape is to pass around two pulleys, (upper sketch). What is max tensile load that it can pull? Tape cross-section is 0.004 in. thick x 0.0625 in. wide.

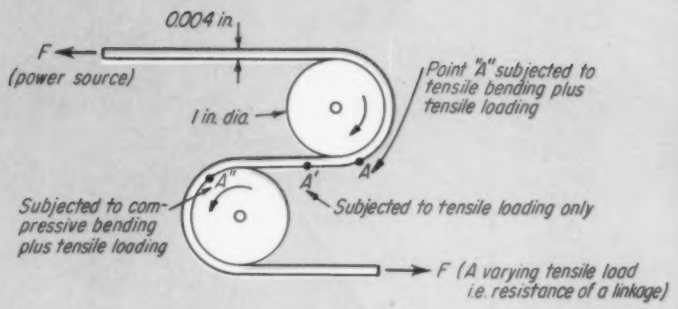
A point on the surface will be subjected to alternating tensile and compressive bending stresses (as point A moves to A′ and then to A″) and also a varying tensile load caused by resistance of the linkage being operated.

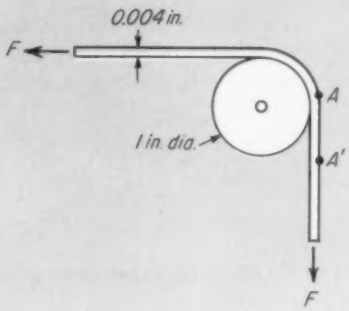
SOLUTION: From Fig 4(A), the intercept of 0.004 in. thickness with the 1-in. pulley curve yields 5 lb as the maximum tensile load allowable for pulling or pushing the linkage. Note that a tape only one-half as thick (0.002 in.) would allow higher loading (12.6 lb).

2—Single Bending

A metal tape is to pass around one pulley, (lower sketch). What is max tensile load that it can pull. Tape is 0.004 in. thick x 0.187 in. wide.

SOLUTION: From Fig 4(B), the intercept of 0.004 in. with the 1-in. pulley curve yields 15.7 lb. This is for a 0.0625-in.-width tape (a 0.0625-in. tape under reverse bending can take only 5 lb, as noted above). For a 0.187-in.-wide tape, max allowable load is 15.7 (0.187/0.0625) = 47 lb.





of tension and compression of equal numerical value were imposed on a specimen. Other strips of the same cross-section were tested at higher and lower stress by varying the diameters of pulleys during the reverse-bending cycle.

Characteristic S-N curves result when the results are plotted with maximum stress as ordinates and the cycles to failure as abscissas. In ferrous materials, these curves are found to have negative slopes for about 10 million cycles, at which point they start to level off. Below the corresponding stress at the level-off point, no fatigue failure should occur, even with an indefinitely large number of cycles.

The endurance limits for both "as-rolled" and "aged" Havar strip, Fig 2, were established by subjecting a strip, 0.002 x 0.059 in. wide to reverse bending over pulleys of increasing diameter, starting with ¼ in. Eventually, a particular diameter was reached that did not yield strip fracture within 12 million complete cycles. A nominal load of 1.18-lb tension (10,000 psi) kept the strip taut at all times.

Allowable stress ranges

Based on these laboratory-derived endurance curves, the stress range limit curves were plotted for use in design computations. Absolute values of the extreme stresses are plotted as ordinates and the average values of the two extremes as abscissas, Fig 3. The endurance limit is plotted above and below the origin, and the tensile strength is plotted as a single point whose ordinate and abscissa both equal the tensile strength. Straight lines are then drawn, connecting the endurance-limit points with the tensile-strength point. Any stress range between these two lines is allowable. Because the yield strength should not ordinarily be exceeded in design, the graph is cut off at this value.

Allowable loads

To translate the permissible stress ranges into useful tensile loads, this formula was employed:

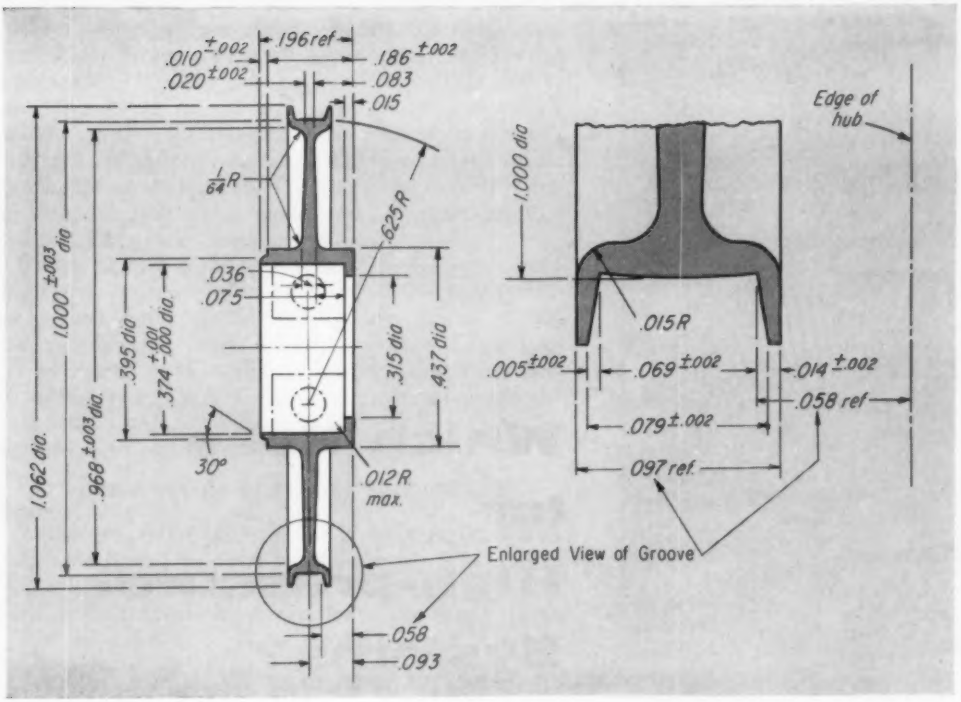
$$S = \frac{E\,y}{(1 - u^2)\,r}$$

where S = Bending stress in the tape, lb/in.²
E = Modulus of elasticity = 30×10^6 lb/in.²
y = ½ tape thickness, in.
u = Poisson's ratio = 0.26
r = pulley radius, in.

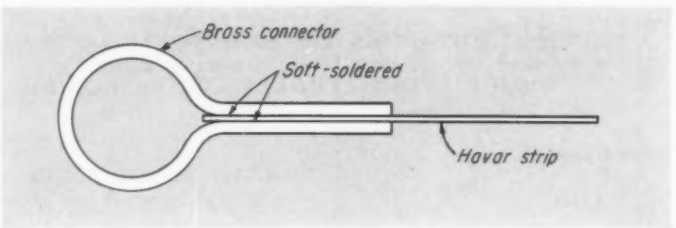
The bending stress in the tape, when subtracted from an allowable stress range (Fig 3), yields the useful tension load that can be applied to the tape. (Useful stress range times cross-section of tape equals useful load range.)

Design curves of max allowable tensile load for aged material, as a function of tape thickness for several pulley diameters, are shown in Fig 4. Both single- and reverse-bending curves are presented for a 0.0625-in.-wide tape. Because the allowable load is proportional to tape width, if the width is doubled, the allowable load would be doubled.

No tape breakage has yet been attributed to the material itself in any instance where the loading was within the allowable limit.



5 . . DIMENSIONS of a 1-in. pulley designed for a 0.059-in.-wide metal tape.



6 . . END CONNECTION FOR METAL TAPE—connector is soft-soldered (say, 50% lead, 50% tin alloy) to the strip by using a liquid-solder flux employed for stainless steels.

Pulley design

Details of a 1-in.-dia pulley designed to work with 0.059-in.-wide tape are shown in Fig 5. This pulley design has given excellent service. The bore has been machined to accept a 0.375-in.-dia x 0.156-in.-width ball bearing. The bearing is pushed into the bore and the projecting lip spun over to capture the outer race. A stud from another machine element carries the assembly.

The tape must be prevented from rubbing the pulley flanges for any extended period because such wear will initiate edge cracks in the tape. A crown of $\frac{3}{8}$-in. radius has kept the tape centered on the pulley.

In the case of bending an isolated thin tape, distortion of the cross-section takes place only near the edges. If the tape is partly wrapped around a smooth cylinder, the edges will curl away from the cylinder.

Inertia of the pulleys can be held to a minimum by machining them from aluminum, 61ST. This alloy will accept a hard anodizing process which imparts a glass-hard surface to the pulley. Also, a dry-film lubricant is usually applied over the "hard coat" surface to ensure max wear-life between pulley and tape.

The end connection for metal tapes, Fig 6, has given reliable service.

Metal tapes have been run in pairs, one on top of the other, in designs where a higher tape tension strength is desired over that available with a single tape (a double-thick tape would greatly increase the internal stresses). The pulley design has been kept the same as that for single-tape operation.

For REPRINT of above article, just check 586 on one of the Reader Service cards found in this issue.

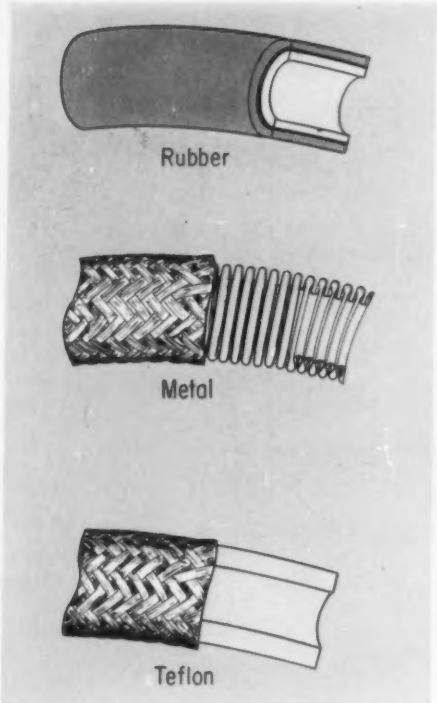
EDITOR'S NOTE: The endurance limit of metal strip employed as a flexible tape is of paramount importance. Check these articles for more information on fatigue analysis and suitable materials:

Endurance Diagrams Speed Fatigue Analysis, Feb 13, '61, p 54—An often-overlooked shortcut that gives an approximate diagram suitable for most ductile steels.

When Stress Fluctuates, This Fatigue Diagram for Safe Limits, Feb 16 '59, p 66—Article presents a graphical way of determining safety factors when fluctuating loads are superimposed on existing stresses.

Seven Closer Looks at Metal Properties, Oct 27 '58, p 48—Discusses compressive, fatigue and tear strengths, strain rates, diaxial stresses, surface defects.

—Nicholas Chironis



Which Hose for High-pressure Systems?

Author gives criteria for selecting among major types: rubber, fluorocarbon plastic, metal.

JOHN LOZZI, *senior applications engineer*
Titeflex Inc, Springfield, Mass

For high-pressure applications—several hundred or several thousand psi—the three major types of suitable flexible hose are rubber, Teflon, and metal. Characteristics and operating conditions of the systems determine which hose will do best; each has its special advantages. For example, some types of rubber take high impulse pressures, Teflon is compatible with practically all fluids, metal can endure wider temperature extremes.

Rubber hose is generally constructed of a natural or synthetic-rubber inner core, reinforced with a fabric or metal braid and covered with a suitable rubber compound. Teflon hose has a thin-wall inner core of the plastic, reinforced with one or more layers of metal braid. The inner core can be a smooth-bore extrusion or a convoluted structure made from Teflon and fiberglass tapes. Metal hose consists of a thin convoluted inner core reinforced with one or more layers of metal-wire braid. This inner core can be made from a wide range of materials, from brass to stainless steel, and may be fabricated from seamless tube, welded tube or strip material.

Selection criteria

The accompanying table lists criteria needed to select a flexible hose from one of the three candidates. In addition to the table, the following details should be considered:

High-temperature operation alone—without considering other factors—is enough to quickly narrow down your choice of hose. The service limit for rubber hose is about 275 F; the fluorocarbon Teflon is suitable to 450 F; metal will take the highest temperature—up to 1000 F.

Subzero temperatures also narrow the field. Rubber hose tends to get brittle below 0 F though it can be specified for temperatures down to −65 F. Teflon retains its flexibility better at subzero temperatures, but in most cases its limit is −65 F. Neither rubber nor plastic should be flexed when operating near its minimum temperature. Metal hose has wider application at low temperature. Certain grades of stainless steel can serve at −300 F, but reduced strength at that temperature must be considered when determining maximum pressure rating.

Fluid compatibility often restricts the use of rubber hose. Some rubber compounds are susceptible to attack by fuels, oils, or synthetic hydraulic fluids. Teflon, on the other hand, is extremely inert, having almost universal chemical resistance, but its over-all compatibility may be limited by the materials used for the fittings. Teflon hose is available with end fittings made of brass, stainless steel, carbon steel (specially treated for corrosion resistance), and even aluminum. One manufacturer offers a line of hose fittings that have steel inserts coated with Kel-F (another well-known fluorocarbon); result is the entire surface in contact with the fluid is inert to acids, chemicals, and solvents.

With metal hose, compatibility is determined by choice of metal for the application. Be sure the metal braid is also compatible. Hydraulic impulse or pressure surge due to pump pulsations, quick-acting valves, or other operating conditions, must be taken into account when selecting the hose. In general, rubber and Teflon withstand higher impulse pressures than metal, although a recently introduced metal hose has a multiple-wall construction that increases its impulse resistance.

Rubber hose is superior in systems having severe pressure surges—impulse peaks exceeding 150% of base operating pressure—although Teflon is a close second. Teflon hose can operate without failure at pressures up to 1500 psi, with peaks to 1875 psi for cycle durations of less than 30 millisec for 250,000 cycles or more. High-pressure Teflon hose with two layers of wire braid is available for 3000 psi, with peaks to 4500 psi.

EXAMPLES OF SELECTION PROBLEMS

PROBLEM

A plastics-molding machine was formerly designed with rigid tubing to convey steam to heated molds. Changing of molds, however, usually involved several hours' work because of the many piping connections. The fluid is steam at 250 psi and 400 F. No appreciable degree of flexing or vibration.

Solution

Flexible hose with quick-disconnect couplings makes it possible to change molds in minutes. Teflon hose was selected because temperature exceeded limits of rubber hose and offered much better resistance to steam. Although metal hose could meet the temperature and pressure requirements, Teflon was chosen because of the longer service life expected.

PROBLEM

Fuel lines for a jet engine afterburner must operate at temperatures up to about 700 F. Pressure does not exceed 500 psi; only nominal pressure surges are involved. Hose must be able to withstand attack from JP fuel and have good bend characteristics to meet critical envelope limitations.

Solution

Flexible hose was needed because of differential thermal expansion. Metal hose was chosen because of temperature requirements. Final decision: a strip-type Monel hose, for resistance to fuel and best combination of weight and bend radius. This hose is available in wall thicknesses down to about 0.006 in.

PROBLEM

The hydraulic system on a die-casting machine operates at pressure of 1000 psi. A pressure analysis shows that surges in this system have pressure peaks ranging up to 10,000 psi at every stroke. Hose should be compatible with synthetic fluids. Rigid plumbing was subject to frequent failures because of vibration.

Solution

In spite of the desire to use plastic hose because of better fluid compatibility, rubber hose was specified for this application because of the impulse-pressure requirement. Neither Teflon nor metal hose could meet this requirement satisfactorily.

PROBLEM

The plumbing system for a rocket engine must be resistant to fuels and oxidizers. Weight-and-space problem is critical. Pressures in all parts of the system are within 1500 psi, with only nominal surge conditions possible. Fluid and ambient temperature are not expected to exceed 400 F.

Solution

Entire engine is plumbed with Teflon hose. Main fuel line, 1½ in. dia, is specified as convoluted Teflon hose—it gives flexibility for tight bends. Remainder of hose is extruded type in diameters up to ¾ in.

THESE CRITERIA FOR FLEXIBLE HOSE

	RUBBER	TEFLON	METAL
Hi-temp Service	275 F max	450 F max	1000 F max
Low-temp Service	−65 F	−65 F	−300 F
Max Operating Pressure (hydraulic hose)	3000 psi	1500 psi, medium pressure; 3000 psi, high pressure	To 3000 psi
Compatibility with Fluids	May require special compounds	Inert to all fluids except fluorine and chlorine at high temp and pressure	Resistant to most fuels and hydraulic fluids
Impulse Resistance (hydraulic)	Can withstand 150% pressure peaks, 100,000 cycles minimum	Can withstand 125% to 150% pressure peaks, 100,000 cycles minimum	Can withstand 125% pressure peaks, 30,000 to 50,000 cycles, approx.
Flexibility (min bend radius)			
½ in. dia	5 to 6 in.	4⅝ in. (extruded)	7 to 9 in.
1 in. dia	9 to 10 in.	3½ in. (convoluted)	11 to 12 in.
Age-, Weather-Resistance	Poor to fair	Excellent—unlimited shelf life	Excellent
Normal Size Limitation	About 2 in. dia or more	3/16 to 1½ in. dia (extruded); ¾ to 2 in. dia (convoluted)	To 6 in.
Typical wt, lb/ft			
½ in. dia	0.5	0.3 (extruded)	0.5 to 0.6
1 in. dia	1.2	0.4 (convoluted)	0.9 to 1.2
Approximate Price, $/ft			
½ in. dia	3 to 4	7 to 9 (extruded)	8 to 9
1 in. dia	5 to 6	30 to 40 (convoluted)	17 to 25

EDITOR'S NOTE: For more information on flexible metal hose, see: **How to Avoid Metal-hose Failure,** July 25 '60, p 43—Author details all known causes of failure, and tells how to overcome them. Included is a bibliography of previous supplementary articles on metal-hose performance—standards, pressure losses, thermal-stress fatigue, and stress-corrosion.

—Frank E Hall

RESONANCE-FREE DATA from your TRANSDUCER

Local resonance in a transducer mounting or nearby panel can obscure the motion you're trying to measure. This simple test will spot the difficulty and provide the data correction you need.

RICHARD E STOREY, *structures engineer*
Missiles and Space Div, Lockheed Aircraft Corp

With the method given here, you need only a few simple laboratory tools—chiefly an oscilloscope and a spring scale—to calibrate your transducers for all dynamic conditions. The method was devised for vibration accelerometers, but also handles dynamic calibration of velocity and position transducers.

WHY CALIBRATE?

There are several reasons why your transducer may not measure what you think it's measuring. The transducer itself may be at fault: temperature may be different from that for which it was designed or response may not be flat over the working range. Or the trouble could lie with the recording equipment—nonlinearities or poor calibration, for example. You can usually avoid errors from these sources by simply choosing high-quality equipment that is designed for the job. But one persistent source of error cannot be removed so easily. What do you do about resonances in the transducer-mounting bracket or in the structure to which it is attached?

Best answer, of course, is to make a sturdier mounting bracket or move the pickup to a more rigid place on the structure. But this isn't always practical. In many cases, you'll have to live with the unwanted resonances and adjust the data accordingly. This means finding the resonance, measuring its influence, and computing some kind of correction factor to apply to the raw data.

One answer: Avoid resonance

Because resonance in the mounting bracket or local structure can introduce uncertainties on the order of 2000%, the first place to start is with a sturdy mounting bracket positioned at a rigid point on the structure. L-shape brackets, though light and reasonably stiff, are less satisfactory than a cubical mounting (see sketches, opposite page). This mounting carries a small weight penalty, but with the miniature, lightweight transducers available today, the penalty is not great and is generally well worth the gain in reliability and quality of data.

A rigid point on the structure is not always easy to find. If the assembly being tested is made mostly of light sheet-metal, you may have to mount the transducer on a compliant panel. If so, the transducer will not necessarily move in phase with the structure and local resonances will mask the true vibration response.

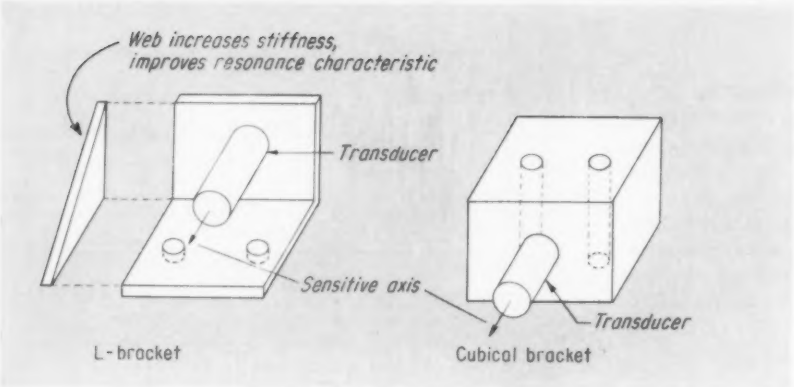
Drawbacks of traditional tests

Your mounting may seem to be very rigid but check it anyway for local resonance. One traditional test, the easiest, is simply to tap the transducer in the direction of the sensitive axis and read the output on an oscilloscope. But this is unsatisfactory. It tends to emphasize a relatively narrow band of frequencies because the force is in the form of an impulse. Also, size of the tapping impulse and its precise wave-shape are unknown—so the data cannot be corrected for the nonlinearity. The only real value of the tapping test is to find out if the transducer is working.

The second common calibration-check—forced vibration with a sine-wave sweep of known amplitude—is more useful but also harder. It requires a small electromagnetic shaker—small enough to have a negligible effect on the structure yet large enough to produce a measurable vibration. One problem with this method is that the shaker must be attached close to the transducer mounting and there may not be sufficient space. Also, though amplitude of the vibration input is small and constant, amplitude at resonance may be enough to exceed capability of the transducer or damage the structure. Moreover, the test takes time—to get an accurate measure of resonant amplitude and frequency, the structure must be driven long enough at each frequency to reach equilibrium.

THE NEW METHOD

Neither of the two common tests, then, are entirely satisfactory. The test we have devised retains simplicity of the first method and accuracy of the second: we apply a single step-force of known amplitude and wave form, and measure the results. The step force excites all frequencies



CUBICAL MOUNTING bracket is the best of these two alternatives. Even with the gussets, L-shape bracket is somewhat compliant, often gives a mounting resonance in the range of a vibration test (less than 2000 cps).

and allows computing how much and what kind of correction to apply to the data. It can be applied directly to the mounting block, so there is no problem of insufficient space. And because of simplicity, time for setting up and testing is minimized.

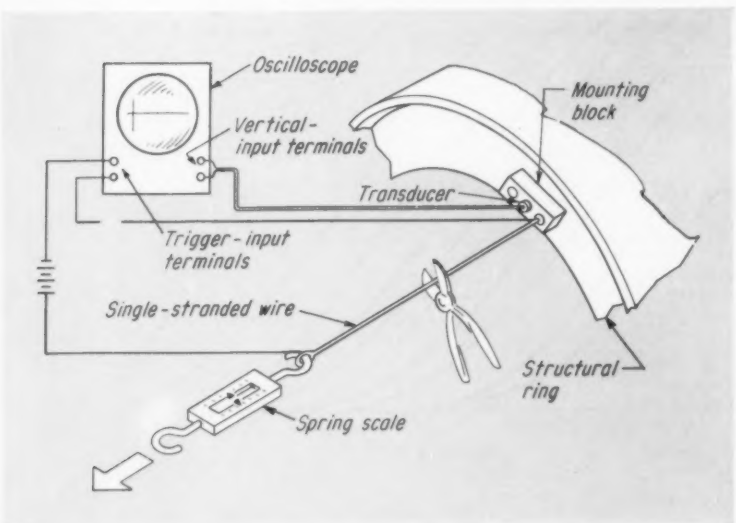
The sketch at the bottom of this page shows a typical test setup. Attach a flexible, single-strand wire, no more than 0.024 in. dia, to the transducer mounting block or the nearby structure, and connect the other end to a spring scale. Pulling on the scale, in direction of the transducer's sensitive axis, load the wire to 10-lb tension (a nominal value—more may be needed for heavy structures) and clamp the scale to a bench or other rigid structure. Now cut the wire with a pair of snips as close to the transducer as physical conditions permit. (Caution —when wire is long and loads are large, the free ends can whip and injure test personnel.)

The wire is connected to the oscilloscope in series with a battery so that when cut, it not only produces the step-force, but also electrically triggers the sweep of the scope. Calibrate both the time (horizontal) and acceleration (vertical)axes of the scope before the test. A Polaroid camera photograph of the oscilloscope face captures the response characteristic.

If the transducer is placed where it is impossible to apply the force directly, the wire can be turned 90° around a smooth metal rod. Experimental evidence indicates this causes a loss of about 20% in the applied load. If this method is used, it should be noted on the data sheet. Also recorded on the data sheet are: horizontal sweep speed, cm/sec; vertical sensitivity, g's/cm; applied force, lb; location and orientation of transducer; structure tested; date of test.

Structural or local resonance?

The peak acceleration recorded on the oscillogram tells whether the resonance is local or a fundamental resonance of the structure. Simply compute the effective mass M_e of the resonant system (the mass moving in phase with the transducer when the step-force was applied) and compare it with real mass of the transducer and mounting bracket. If M_e is less than about 10 times the transducer's mass, the resonance is probably local, and either the mounting or the panel are at fault. The effec-



COMMON LABORATORY EQUIPMENT—a spring scale and oscilloscope with trigger input — are all that's needed to find out whether there are local resonances in the transducer mount or nearby structure. If the resonance is local (vibrating mass much smaller than mass of structure) readings from these two pieces of equipment will tell how to correct the transducer data to eliminate the unwanted resonance.

tive mass is found by the following equation:

$$M_e = \frac{F}{a_{max}}$$

where F is step-force and a_{max} is peak acceleration.

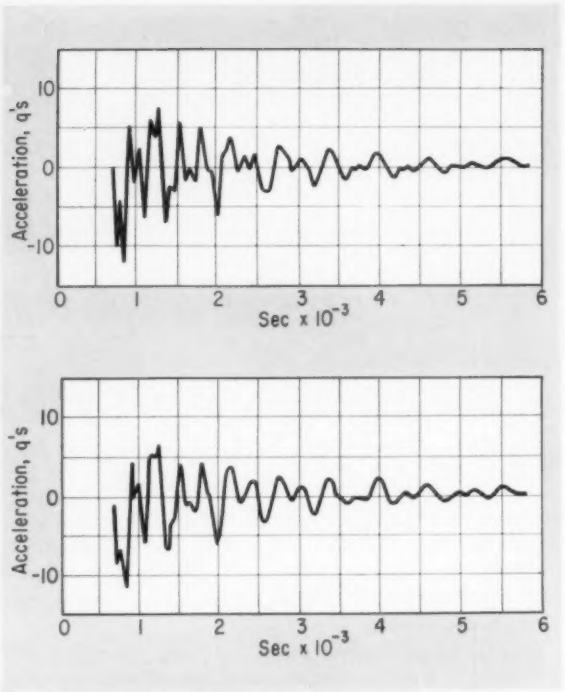
If the resonance is local and there is no possibility of relocating the transducer or beefing up its mounting, you will have to correct the transducer data for the effect of the local resonance with data from the step-force test.

Effect of resonance on vibration data is shown by the transmissibility curve. It is a plot of the amplitude ratio —amplitude of force transmitted to the structure, divided by amplitude of the applied force. The transmissibility curve is described by the equation.

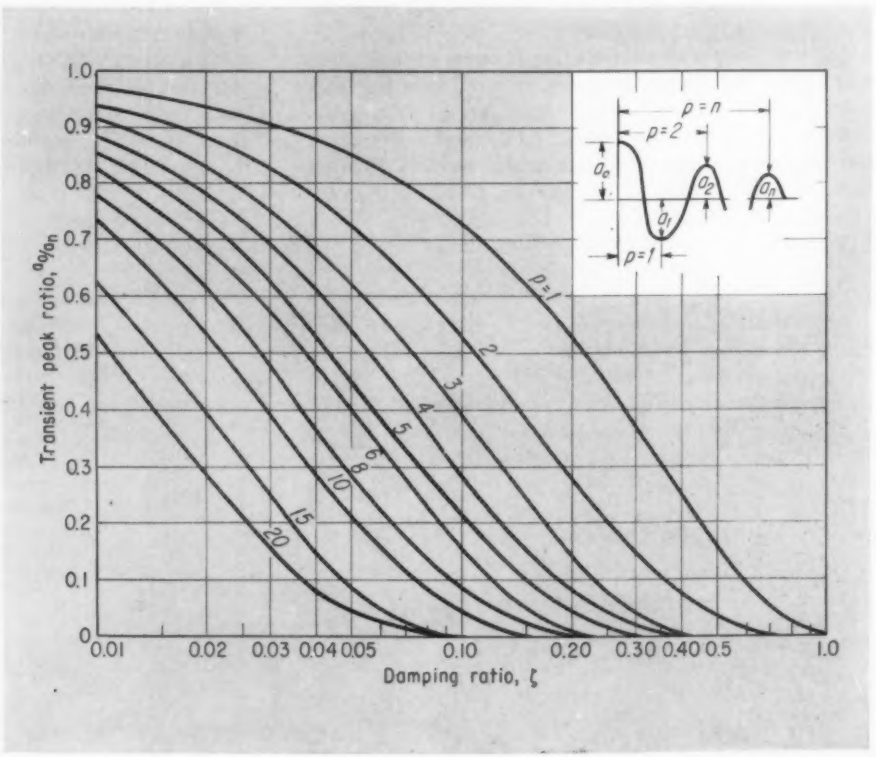
$$AR = \sqrt{\frac{1 + (2\zeta r)^2}{(1 - r^2)^2 + (2\zeta r)^2}}$$

where AR is amplitude ratio, r is frequency at any point divided by the resonant frequency, and ζ is damping ratio. Read the damping ratio from the chart below. It is plotted as a function of the ratio of two successive peaks on the oscillograph, a/a_n, and the number of half-cycles, p, between.

The square of the amplitude ratio for each frequency, divided into the recorded vibration data (expressed in gravities squared per cps), will give the corrected vibration data. This correction is approximate but close enough for most applications. The computation is usually best handled by analog computer. The example on the next page shows solution of a typical problem.

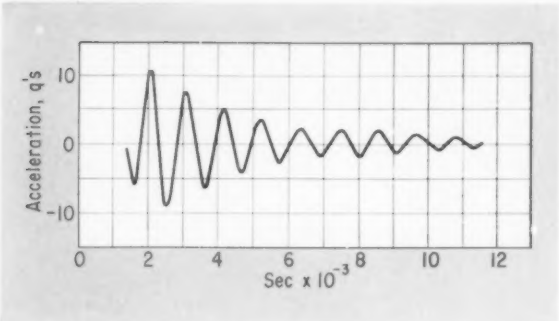


REPEATABILITY of step-force test is very good, as shown by these two near-identical oscillograms. Both indicate a maximum acceleration of about 12 g and resonant frequency (counting positive-going traces that cross the ordinate and dividing by time interval) of about 3200 cps.



EXAMPLE—CORRECTING DISTORTED TRANSDUCER DATA

A 10-lb step-force test produces the oscillogram shown below.

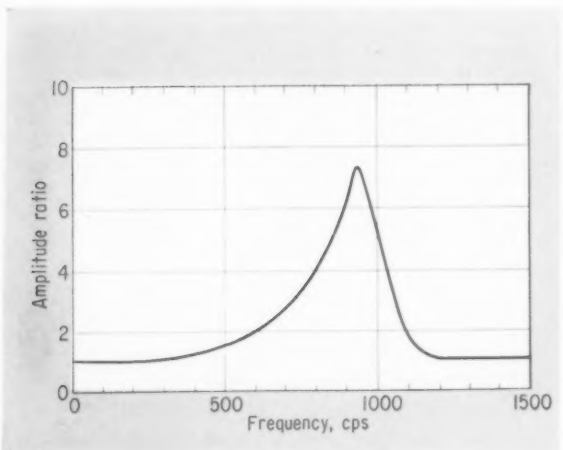


This graph indicates that the resonant frequency is 900 cps. From the peak acceleration shown on same oscillogram, effective mass of the resonant system = 10/11 = 0.91 lb/g.

The accelerometer and its mounting bracket weigh 0.2 lb, so ratio of effective mass to real mass is 0.91/0.2 = 4.55.

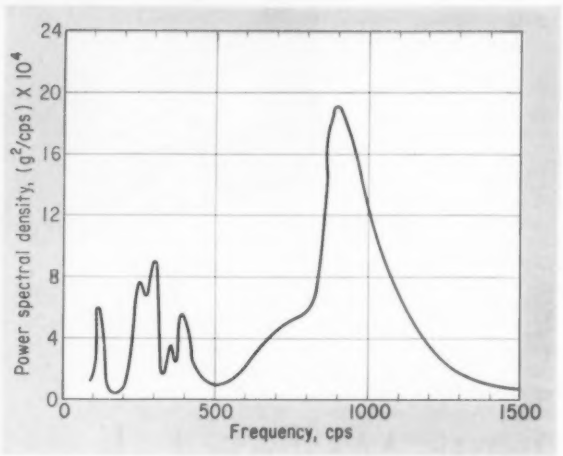
Because the vibrating mass in the step-force test is largely the mass of the accelerometer and nearby structure (mass ratio less than 10) the local resonance will distort any vibration data from this transducer. In this example it happens to be impossible to relocate the transducer to a more rigid position on the structure and the mounting bracket has already been made as stiff as possible. Therefore, the vibration data must be corrected to eliminate the effect of this local resonance.

The oscillogram shows that ratio between peak 0 and peak 4 is 5/11 = 0.45. For a peak ratio of 0.45 and p = 4, the graph shows that the damping ratio is 0.07. Substituting this into amplitude ratio equation and solving for various frequencies gives this transmissibility curve.

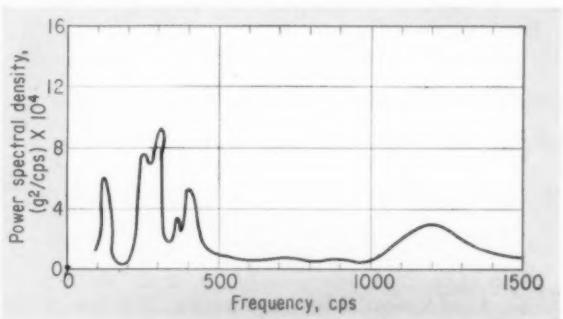


The curve should drop below AR = 1 at frequencies above 900 $\sqrt{2}$ cps but it was arbitrarily limited to AR = 1 because there are probably additional resonances in the system above this frequency.

When the structure is tested, a recording of the power spectral density distribution looks like this.



Notice the peak at 900 cps and similarity between shape of the curve in this range and shape of the transmissibility curve. Dividing the values of the power spectral density distribution by the square of the calculated amplitude ratio gives the following corrected curve.



This is corrected vibration response of the structure.

EDITOR'S NOTE: Your oscilloscope is also valuable for other kinds of vibration checks. For a roundup, see:

Structural Vibration—an Oscilloscope Tells the Story in Pictures, Feb 2 '59, p 52—Quick tests show where resonance occurs, where the troublespots are, and what causes them.

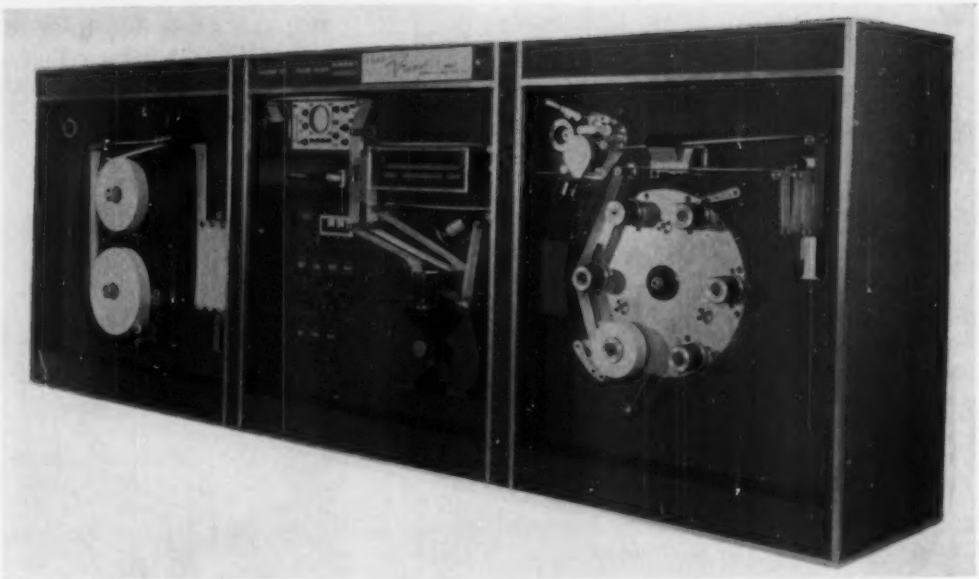
Also see:

How Good are Random Vibration Tests? Dec 5 '60, p 82—The disadvantages of random-wave tests, and why sine tests are adequate for most applications.

Vibrators—4 Types, Mar 7 '60, p 40—A comparison of electric, hydraulic, mechanical, pneumatic vibrators—and which to choose for the job.

—Charles J Lynch

PRODUCT DESIGNS

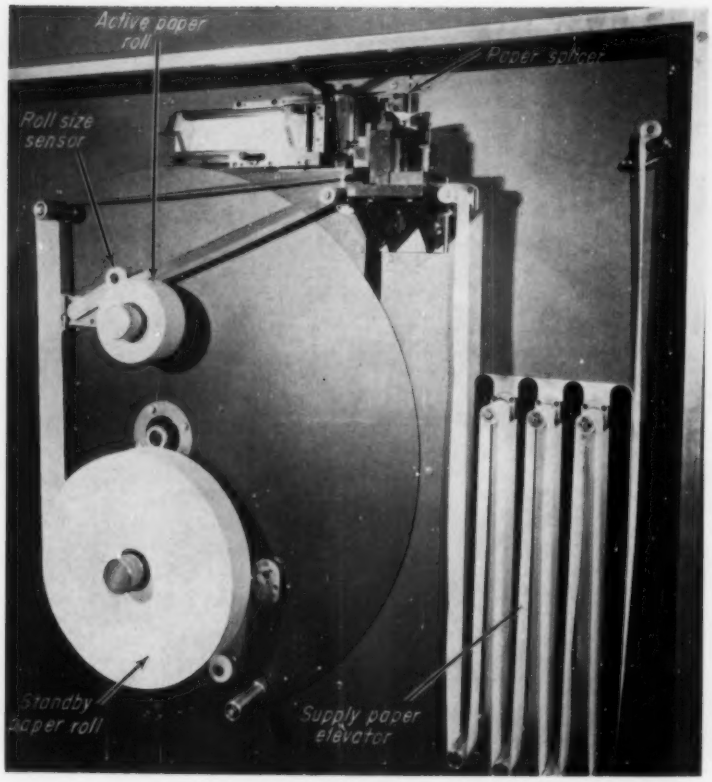


Prints Mailing Labels at Computer Speed

Automated paper-transport system feeds tape continuously through this high-speed nonimpact printer. Forming images electrostatically, the unit produces 36 address labels per second from digital-pulse input.

Housing equipment such as the three elements that make up this label-printing system presents packaging problems similar to those of the computer equipment with which it is used. Computers have already developed a tradition of cabinetry that conceals all but tapehandling sections, control consoles and display panels. A B Dick designers decided that the simplest way to assure maximum accessibility and ease of monitoring and servicing (such as placing new tape rolls on handler every 30 min.) was to leave the mechanical and printing elements exposed. This results in a "single-side" machine—all operating functions are performed at the front. Designers went further and allowed these components to form the basis of machine appearance, achieving an uncluttered simplicity that emphasizes the product's highly engineered character.

LABEL PRINTER consists of two major units. The Tape Reader Buffer Unit, or TRBU, reads the magnetic tape records, edits the information read, stores the printing information until used by the printer, and assembles the printing data for transmission to the printer. These functions are accomplished by editing, logic, and buffer circuits which permit the printed to be driven directly from the master-file records produced by the computer. The Label Printer converts digital codes received into printing signals and produces the magazine address labels continuously. New paper rolls are inserted and printed label rolls removed without stopping the machine.

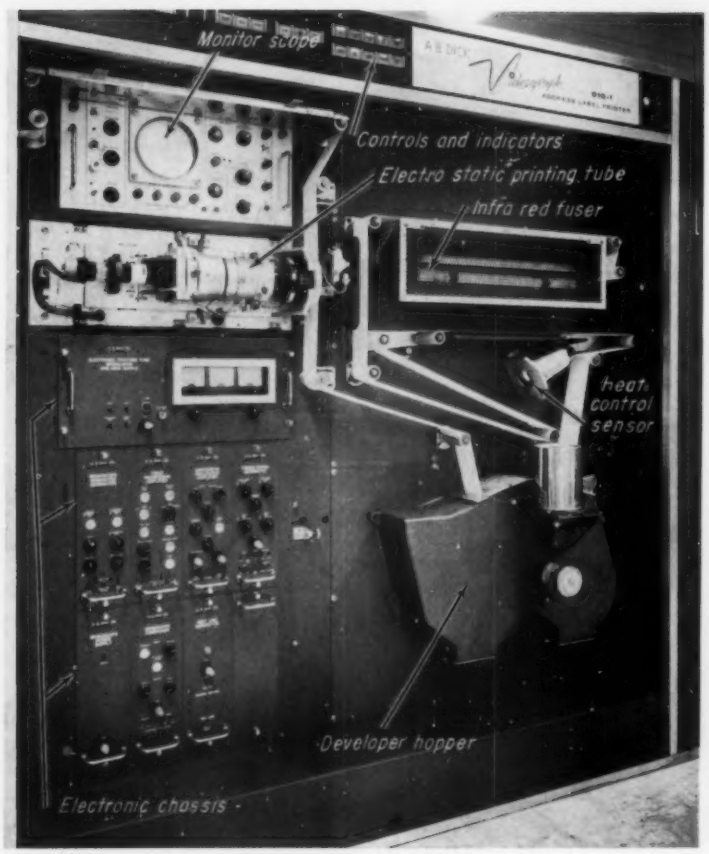


PAPER SUPPLY in bay 1 of the printer has two rolls of paper mounted on the supply turret. The upper roll is in what is called the "active" station. The web passes through the splicer, around the paper-elevator capstans, and into bay 2. The paper elevator provides a reserve supply to allow the system to continue to operate when the web transport is stopped momentarily in bay 1 during each automatic splice.

To prevent the large supply rolls from "free-wheeling," magnetic braking is applied to the arbor, or hub, from which the active roll is unwinding. A roll-size sensor adjusts the braking current as the roll unwinds. The larger the roll, the greater the braking effect.

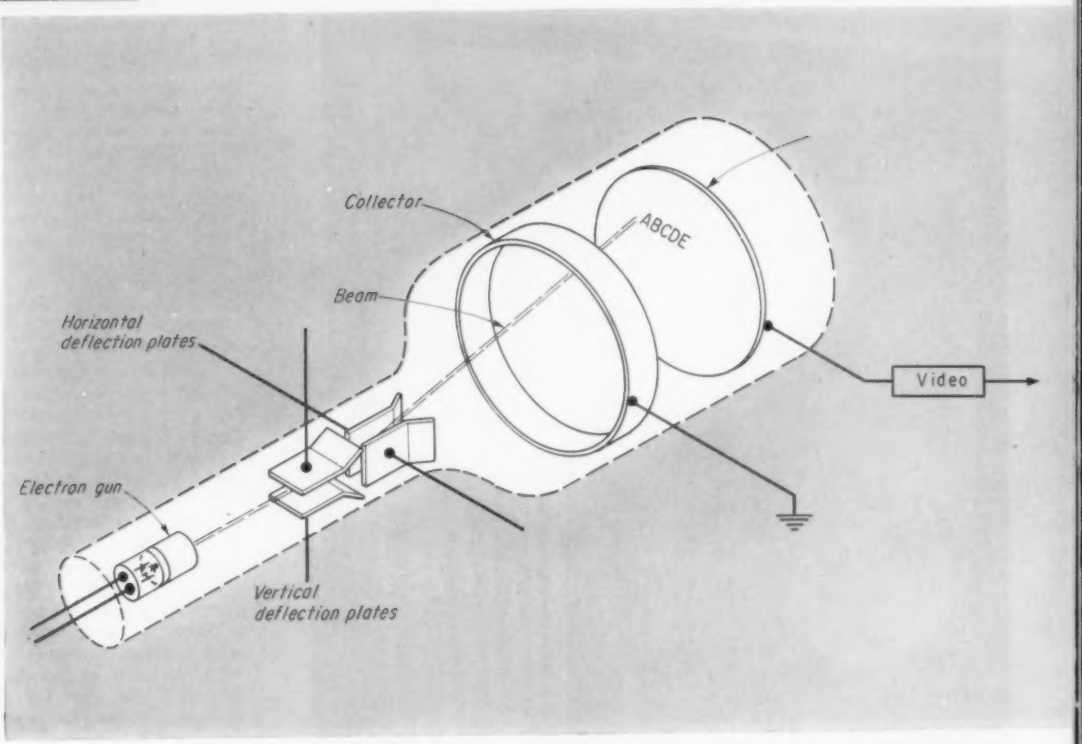
Four microswitches operated by the elevator serve as protective devices for the system. One switch prevents the splicer from operating and stops the machine if there is not enough paper in the elevator to allow the splice to be made without breaking the web. A second switch actuates the adjustable magnetic-braking circuit for each new active roll. A third applies "maximum" braking current to the hub of the old roll after each splice. The fourth switch stops the printer if web tension is lost.

When the active roll is nearly unwound, sensor stops the paper and actuates splicer which lap-splices the standby roll to the active roll and cuts off the old roll. After splicer releases the paper and transport resumes, the supply turret indexes the standby roll into the active station.



PRINTING, DEVELOPING, AND FIXING take place in bay 2. The web is routed past the electrostatic printing tube at 36.5 in./sec; electrostatic latent image of each address label is formed on the moving web. The web then passes around a drum in the developer hopper where dyed resin toner is deposited on the electrostatically charged latent image. The fuser-oven fixes the image on the paper. Elevator, (shown in the down position) rises when the fuser lamps are lighted, lifting the web to the fusing position. Voltage on the fuser lamps is controlled by the heat-control sensor. Should the web break or printer stop, interlocks open the fuser-lamp circuits and drops the fuser elevator to protect the paper web.

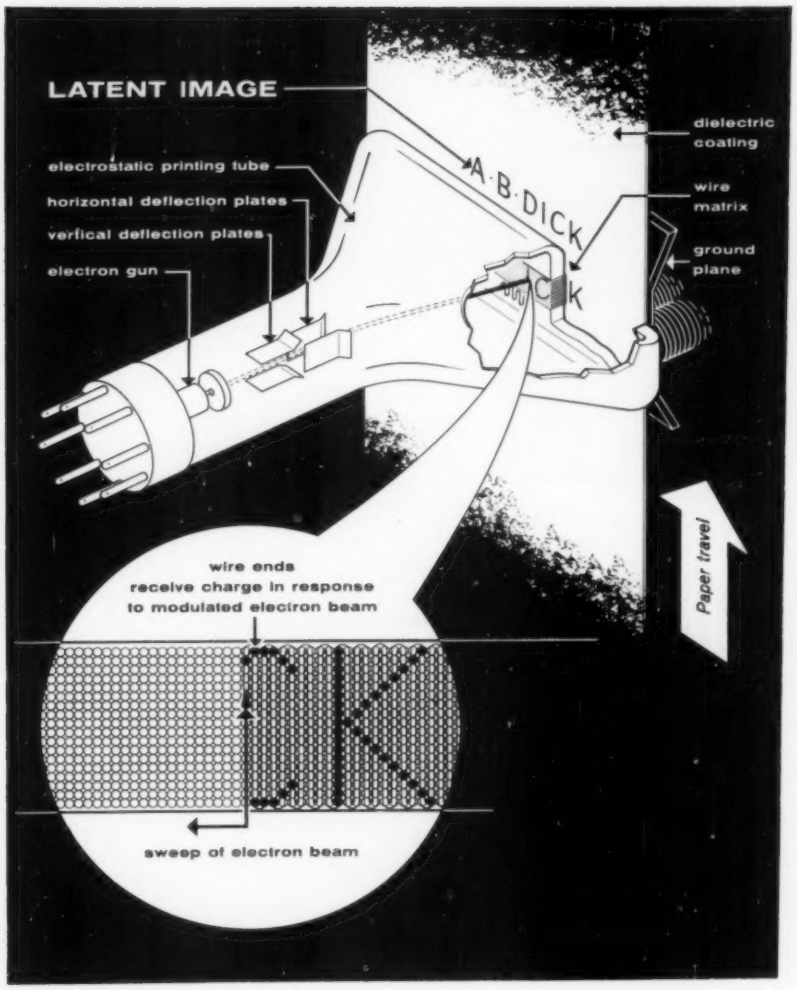
Monitor scope permits observation of the image being printed. Although the subscribers' names and street addresses are an unintelligible blur, the city and state portion of the address remains the same for many successive labels, producing a steady image that can be read and adjusted.



PAPER WEB entering bay 3 passes through main-drive mechanism where rubber rollers provide pressure for friction drive. Holes are punched at regular intervals along the web—between each address—to guide the machine that cuts and applies the finished labels. Dies disposed radially around the main drive drum mate with punches in the punch holder. As each hole is punched, a signal pulse is generated to release another address record to the printer.

The web then enters a paper elevator which compensates for variations in takeup speed, and is next fed onto a turret assembly with six spindles. Rolls build up on the takeup reel in the 7 o'clock position. When an end-of-roll signal is received from the computer tape, the web is cut by a solenoid-operated knife at the 9 o'clock position. At the same time a roller follower holds the paper against a hollow plastic core on the takeup spindle. Vacuum applied through perforations in the plastic core holds the free end of the tape until seven or eight turns have been completed. The turret then indexes 60 degrees to locate the takeup reel at the 7 o'clock position. This positions an empty reel in the 9 o'clock cutoff position for the next end-of-roll signal.

Stroboscope between elevator and turret permits operator to check finished labels and perforation location. Roll-size sensor contacts the takeup roll in the 7 o'clock position and prevents cutoff until minimum web length is wound on spindle (500 labels). If an end-of-roll signal is missing, cutoff will occur and a new roll will be started when a maximum size roll (15,000 labels) is on the reel. If takeup reel exceeds dimensions the sensor will halt data flow and cuts web.



MONOSCOPE TUBE that converts digitally coded information into video-type signals is basically a cathode-ray tube. At the screen end of the tube, a circular aluminum disk replaces phosphers as the target for the electron beam. The aluminum target contains a square array of 64 characters printed on its front surface. As the primary beam scans a single character in a raster-like pattern, a video signal corresponding to the shape of the character is produced. An identical raster scans the electrostatic printing tube. The intensity of the beam is modulated with the video signal. This produces an electrostatic image of the character being swept by the monoscope primary beam on the videograph paper. Target of electron beam in electrostatic printing tube is a matrix of closely spaced stainless-steel wires bonded in the glass face of the tube. The wires in the matrix are 0.001 in. dia and are spaced 250 per in. vertically and horizontally. Printing resolution is determined by dia and current density of the electron beam.

The 64 alphanumeric characters and symbols are arranged in 8 columns of 8 characters each. The primary beam is guided to the desired one by an appropriate combination of the horizontal and vertical deflection voltages obtained by the character generation circuits. (Any one of 8 voltage levels can be sent to each plate.) Characters are selected at the order of the master tape which sends a six-bit digital code for each. The first three bits select a vertical deflection voltage and the last three select the horizontal voltage.

Since the aluminum target plates can be easily produced from original artwork by printing techniques any type font may be used. Type fonts can be varied by switching monoscope tubes to meet special printing needs.

PS . . . Label printer is designed to operate directly from magnetic-tape master-file records without preparation of a pre-edited computer tape. Unit produces completed address-label rolls ready for use by magnazine publishers in the standard label-affixing machines. When operating at a basic rate of 6100 characters per second, the machine prints 36 labels per second, or five million labels during a standard 40-hr week.

The monoscope tube is the heart of 1 cu-ft character-generator that converts digital signal input into alphanumeric information. The device can be used in connection with cathode-ray display tubes, or electro-static printing tubes. The generator is capable of generating 20,000 symbols per second for display systems, as well as print-out equipment. These basic types of data-processing equipment are also applicable to copy reproduction, information retrieval, plotting—printing of scientific and engineering data, photographic printing, document scanning and display. Videograph Address Label Printer Model 910 was produced for Time Inc by A. B. Dick Company, Chicago.

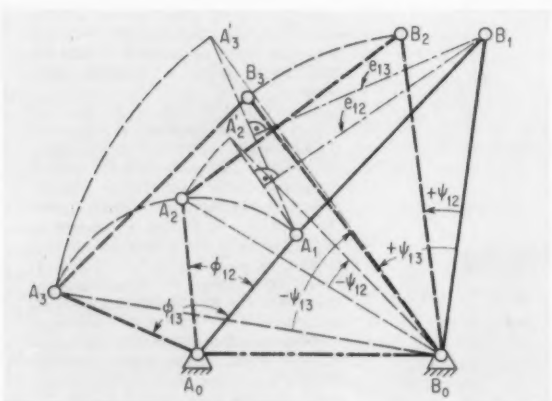
nine lectures on
MECHANISMS

1...SPRING MECHANISMS–force analysis
2...SPRING MECHANISMS–point balancing
3...SPRING MECHANISMS–continuous balancing
4...POWER CYLINDER MECHANISMS–full stroke
5...POWER CYLINDER MECHANISMS–intermediate positions
6...FEEDER MECHANISMS–types
7...FEEDER MECHANISMS–applications
8...FEEDER MECHANISMS–angular motions
9...FEEDER MECHANISMS–curvilinear motions

8...FEEDER MECHANISMS—
angular motions

How to use four-bar linkages to generate continuous or intermittant angular motions required by feeder mechanisms.

H SCHAEDLER AND G MARX
Institute for Fundamental Research
Brunswick, Germany
Translated by F R Erskine Crossley, Yale University



1 . . . **FOUR-BAR LINKAGE** synchronizes 2 angular movements, ϕ_{12} and ϕ_{13}, with ψ_{12} and ψ_{13}.

In feeder mechanisms it is often necessary to synchronize two sets of angular motions. A four-bar linkage offers one way. For example, in Fig 1 two angular motions, ϕ_{12} and ϕ_{13}, must synchronize with two others, ψ_{12} and ψ_{13}, about the given pivot points A_0 and B_0 and the given crank length A_0A. This means that crank length B_0B must be of such length that the resulting four-bar linkage will coordinate angular motions ϕ_{12} and ϕ_{13} with ψ_{12} and ψ_{13}. Procedure is:

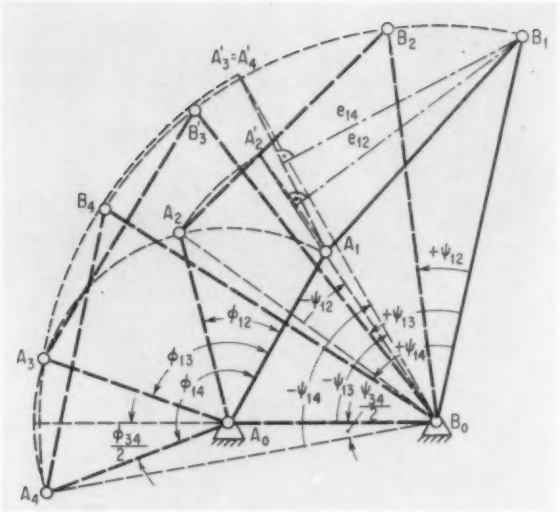
1. Obtain point A'_2 by revolving A_2 about B_0 through angle $-\psi_{12}$ but in the opposite direction.

2. Obtain point A'_3 similarly by revolving A_3 about B_0 through angle $-\psi_{13}$.

3. Draw lines $A_2A'_2$ and $A_3A'_3$ and the perpendicular bisectors of the lines which intersect at desired point B_1.

4. The quadrilateral $A_0A_1B_1B_0$ represents the four-bar linkage that will produce the required relationship between the angles ϕ_{12}, ϕ_{13}, and ψ_{12}, ψ_{13}.

Three angles with four relative positions can be synchronized in a similar way. In Fig 2 it is desired to synchronize angles ϕ_{12}, ϕ_{13}, and ϕ_{14} with corresponding angles ψ_{12}, ψ_{13}, and ψ_{14}, using freely chosen pivot points A_0 and B_0.



2 . . . THREE ANGULAR POSITIONS, ϕ_{12}, ϕ_{13}, ϕ_{14}, are synchronized by four-bar linkage here with ψ_{12}, ψ_{13}, and ψ_{14}.

In this case crank length A_0A as well as B_0B is to be determined, and the procedure is:

1. Locate pivot points A_0 and B_0 on a line that bisects angle $A_3A_0A_4$, the length A_0B_0 being arbitrary.

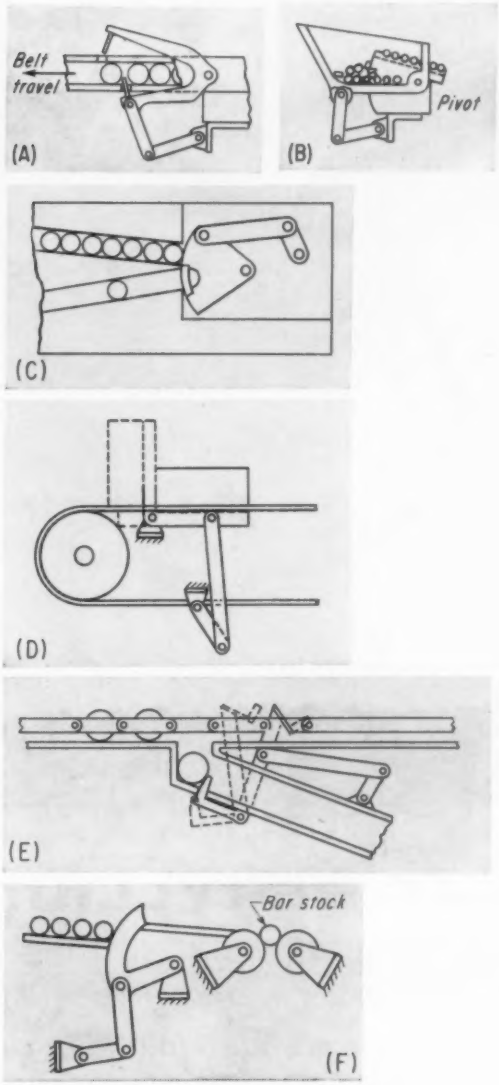
2. Measure off $\frac{1}{2}$ of angle $B_3B_0B_4$ and with this angle draw B_0A_4 which establishes crank length A_0A at intersection of A_0A_4. This also establishes points A_3, A_2 and A_1.

3. With B_0 as center and B_0A_4 as radius mark off angles $-\psi_{14}$, $-\psi_{13}$, $-\psi_{12}$, the negative sign indicating they are in opposite sense to ψ_{14}, ψ_{13} and ψ_{12}. This establishes points A'_2, A'_3 and A'_4, but here A'_3 and A'_4 coincide because of symmetry of A_3 and A_4 about A_0B_0.

4. Draw lines $A_1A'_2$ and $A_1A'_4$, and the perpendicular bisectors of these lines, which intersect at the desired point B_1.

5. The quadrilateral $A_0A_1B_0B_1$ represents the four-bar linkage that will produce the required relationship between the angles ϕ_{12}, ϕ_{13}, ϕ_{14} and ψ_{12}, ψ_{13}, ψ_{14}.

The illustrations show how these angles must be coordinated within the given space. In Fig 3(A) input angles of crank must be coordinated with output angles of forked escapement. In (B) input angles of crank are coordinated with output angles of tilting hopper. In (C) input angles of crank are coordinated with output angles of segment. In (D) a box on a conveyor is tilted 90° by output crank, which is actuated by input crank through coupler. Other mechanisms shown similarly coordinate input and output angles—some have dwell periods between the cycles, others give linear output with dwell periods.



3 . . . INPUT AND OUTPUT angular movements of feeder mechanisms are synchronized by four-bar linkage. (A) Separate feed of spherical or cylindrical parts on a conveyor. (B) Group-sorting of spherical parts by the tilting hopper. (C) Separate feed of spherical or cylindrical part by gravity. (D) Rectangular parts are turned on a conveyor. (E) Parts are separated by levers, and conveyor movement is controlled by trigger at right. (F) Bar stock is positioned by angular oscillation of output lever when input crank is actuated.

From the text for the Refresher Course in Mechanism 1959/1860, arranged and sponsored by the Chamber of Commerce & Industry of the City of Brunswick, Germany, in cooperation with the Division of The Science of Mechanism of the Society of German Engineer (VDI). Course director: Kurt Hain.

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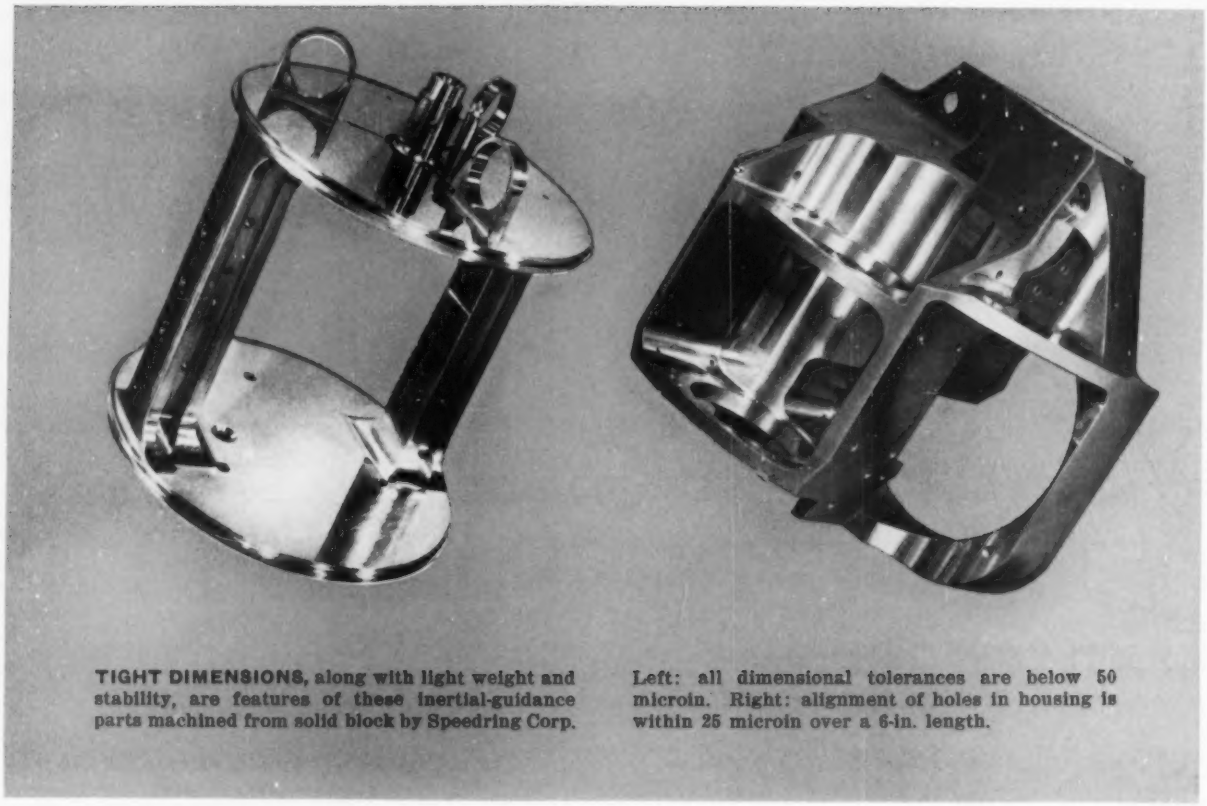


TIGHT DIMENSIONS, along with light weight and stability, are features of these inertial-guidance parts machined from solid block by Speedring Corp.

Left: all dimensional tolerances are below 50 microin. Right: alignment of holes in housing is within 25 microin over a 6-in. length.

WHAT BERYLLIUM CAN DO FOR YOU

Commercially, it's newest of the lightweight metals. Its high tensile strength and high elastic modulus challenge titanium and the ultrahigh-strength steels in strength-to-weight ratio. Specifically, here's a rundown on what beryllium offers.

PAUL E GAGE, *development engineer, The Beryllium Corp*

With its unique combination of properties, beryllium metal is rapidly broadening its field of applications. No longer exclusively a nuclear material (valued for its low neutron absorption) it has emerged to find jobs of many special types–where its properties can offset its high cost and need for special handling.

New applications for beryllium are based on profiting from several rather than any one of its characteristics. Basically, it offers:

- Low density–only slightly more than magnesium
- High elastic modulus–40% higher than alloy steel, 2½ times that of titanium
- Good thermal conductivity–approaching that of aluminum
- High specific heat–higher than any other metal
- Strength, which is retained at elevated temperatures (more than half its yield strength remains at 1000 F)
- Oxidation resistance up to 1400 F

Design applications for the metal can be divided into two categories. In one, beryllium is used mainly for its mechanical properties; in the other, for its physical properties.

Mechanical-property applications

Because ratio of beryllium's tensile strength to weight is highest of any metal, this metal offers minimum struc-

REPRINTED—Circle 585, inside back cover

tural weight under static tensile loads. However, beryllium is notch-sensitive, requiring special care in design. For example, research at Standard Pressed Steel developed beryllium bolts using a shallow 55% thread and a special post-treatment—shot peening and an electrolytic polish. These bolts can be stressed to the limit of their tensile strength.

Lightweight strength is also useful in high-speed rotating elements because it lowers starting inertia, decreases power consumed to maintain speed, and decreases centrifugal forces on the part.

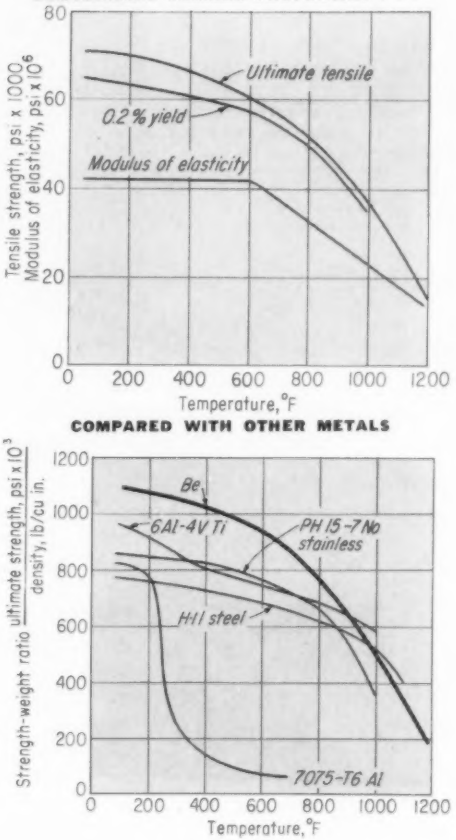
An expansion coefficient close to that of steel makes beryllium parts compatible with mating parts of steel—for example, beryllium rotors can be used with steel bearings. Further, high thermal conductivity minimizes temperature gradients within the part.

Beryllium is dimensionally stable and its low deformation under creep loads make it stand out for super-precise parts such as those in gyros.

Where most of the structure consists of compression members, a good basis when comparing materials for structural efficiency is this ratio: density divided by square root of the elastic modulus. A good lightweight design will have a structural weight that roughly reflects this ratio. The third line in the table below compares this ratio for beryllium and other pure metals with that of aluminum. It allows a valid comparison because moderate amounts of alloying will not substantially change density or modulus of elasticity.

A higher resonant frequency will result when material for a part is changed from another metal to beryllium. This is because beryllium's high stiffness (modulus-to-

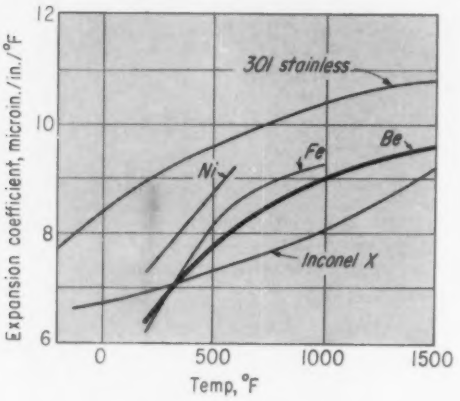
BERYLLIUM'S TENSILE PROPERTIES . . . COMPARED WITH OTHER METALS

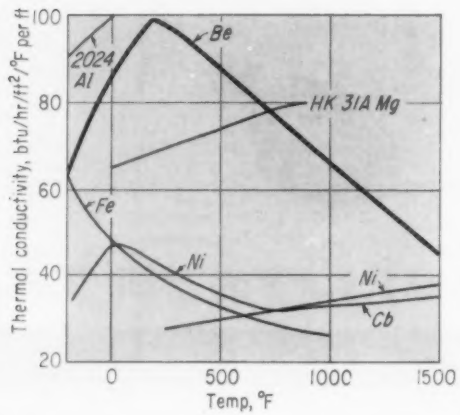


COMPARISON OF PROPERTIES—BERYLLIUM AND OTHER METALS

		LIGHT METALS				MEDIUM-WEIGHT METALS						HEAVY METALS			
PROPERTY	BERYLLIUM	MAGNESIUM	ALUMINUM	TITANIUM	VANADIUM	ZIRCONIUM	IRON	CHROMIUM	COLUMBIUM	NICKEL	MOLYBDENUM	COPPER	RHENIUM	TUNGSTEN	HAFNIUM	TANTALUM
Density (D), lb/in³	0.066	0.0628	0.10	0.17	0.217	0.231	0.283	0.260	0.310	0.322	0.369	0.324	0.743	0.697	0.411	0.601
Mod. of elast. (E), psi x 10⁶	42	6.5	10.6	16.7	24	12	29	41	23	31	52	16	75.2	50	12.1	27
Rel. Wt. compared to Al, $D/\sqrt{E}$	0.332	0.84	1.0	1.35	1.44	2.17	1.71	1.34	2.10	1.88	1.66	2.64	2.79	3.21	3.84	3.76
Specific Heat at 70 F, btu/lb/°F	0.43	0.25	0.215	0.137	0.127	0.069	0.11	0.11	0.065	0.105	0.061	0.092	0.035	0.032	0.035	0.033
Heat of Fusion, btu/lb	467	160	170	187	142	109	117	136	—	133	126	91	—	110	—	—
Thermal Coef. Lin. Exp. at 70 F, microin./in./°F	7.4	14.4	13.2	4.72	4.62	2.78	6.51	3.45	3.95	7.4	2.84	9.2	3.73	2.45	3.28	3.62
Thermal Conduct., btu/hr/sq ft/°F per ft	96.7	92.0	122	99.2	16.9	13.8	43.6	38.7	31.9	53.2	77.4	227	—	96.8	—	31.5
Thermal Conduct. near 20 C, % of Copper	42	40	53	44	7	6	19	17	14	23	34	100	—	43	—	14
Electrical Resist. near 20 C, microhm/cm	4.3	4.5	2.7	47.8	25	42	9.7	13	13.1	6.8	5.2	1.7	19.3	5.5	9.7	12.4
Electrical Conduct., % I.A.C.S.	40	39	65	4	7	4	18	13	13	25	33	100	87	31	5	14
Thermal Neutron Absorpt. Cross-section, barns/atom	0.009	0.059	0.215	5.6	4.7	.18	2.43	2.9	1.1	4.5	2.4	3.59	84	19.2	115	21.3
Atomic Weight	9.02	26.32	26.97	47.90	50.95	91.22	55.85	52.01	92.91	58.69	95.95	63.54	186.31	183.92	178.6	180.95

BERYLLIUM PHYSICAL PROPERTIES— WHERE THEY FIT IN





density ratio) and the fact that resonance varies with stiffness. This shift in resonant frequency is immediately apparent in two applications:

It increases sensitivity of instruments that measure by an inertial mass—accelerometers, for example. To measure external forces accurately, mechanical resonance of the inertial (seismic) mass must be one octave higher than frequency of the force.

It can prevent vibrations from building up large amplitudes of fatigue stress. This is particularly useful in missile or aircraft where high-intensity noise can cause resonance.

At intermediate temperatures, up to 1000 F, beryllium's strength-weight ratio is higher than that of most other metals. Although tensile strength falls off as with other metals, the ratio at 600 F is at least 25% higher than that of beryllium's closest competitors: 6Al-4V titanium and PH 15-7 Mo stainless. Further, beryllium resists oxidation in air to 1400 F.

Physical-property applications

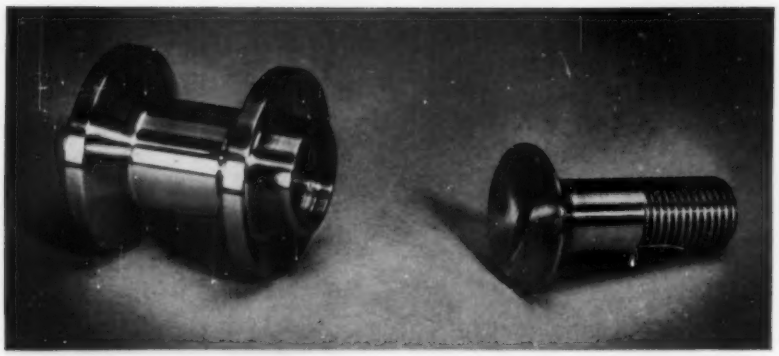
Above 1200 F, beryllium is used mainly for its physical and thermal properties. This metal provides an efficient heat sink because of its high specific heat, good thermal conductivity, and melting point (above 2300 F). Its high specific heat—over twice that of the other metals—allows it to remain relatively cool, to absorb heat with a minimum rise in temperature.

Beryllium's coefficient of thermal conductivity, close to that of aluminum, conducts heat away from the hot surface to allow uniform absorption by the entire metal structure. However, thermal conductivity of copper is over twice that of beryllium. Choice between the two as a heat sink depends on whether the material contributes to structural strength and how much weight penalty can be tolerated. As part of the structure, copper would weigh eight times more than beryllium. This means that the entire structure of copper will absorb 70% more heat for the same temperature rise. But for a given weight, beryllium has a clear superiority.

From 1500 F to melting, these thermal properties are

MECHANICAL PROPERTIES OF BERYLLIUM

	Vacuum Hot-Pressed	Extruded and Annealed	As-extruded, 1 in. bar	Cross-Rolled	Forged
Ultimate Tensile Strength, psi	40,000	70,000	97,000	75,000	70,000
Yield Strength, 0.2% Offset, psi	30,000	45,000	47,000	50,000	40,000
Elastic Modulus, psi	42 x 10^6	42 x 10^6	42 x 10^6	42 x 10^6	42 x 10^6
Percent Elongation	1	10	12	15	5
Rockwell Hardness	B80	B90	B90	B100	B95



PRECISION THREADS machined into extruded bar by American Beryllium Co. Spool has internal thread with 92 pitch and 0.0005 total pitch-diameter tolerance; screw has 32-pitch thread with finish of 8 microin. rms.

valued along with such other physical properties as neutron-absorption. Promising applications here include fire walls, moderators and reflecting shields in reactors; limitations are that the metal has low mechanical strength and must be protected from oxidation.

Beryllium is the only metal that can be used both as moderator and reflector in a nuclear reactor. It increases reaction efficiencies because it moderates (slows down) fast neutrons to speeds that will cause additional fission and also bounces back these neutrons into the reactor core. Here, beryllium's low atomic weight and low neutron cross-section meet the requirements. Future for beryllium in this field shows promise in advanced gas-cooled reactors designed to operate at 800 to 1200 F. At these temperatures, the metal's mechanical and thermal properties will give it important advantages.

Different forms of the metal

Mechanical properties of beryllium vary with the method used to fabricate it. The various forms usually start from a powder hot-pressed in vacuum, which is about 98% pure metal, 1.8% beryllium oxide and about 0.2% other impurities. Mechanical strength and ductility are raised by hot working at about 1400 F. This working is kept below the recrystallization temperature to avoid forming large brittle grains, which fracture easily. Properties of the as-pressed metal and three worked forms are given in the accompanying table.

Fabricating beryllium parts from sheet can be deceiving. Though soft, the sheet is also brittle—cold forming is limited to a few percent before fracture. Even in shearing, sheet heavier than 0.020 in. should be cut at above 1000 F to avoid cracking. Bending, deep drawing, brazing and welding should follow special procedures.

One problem has been to produce sheet beryllium of uniform gage thickness. Up to now the hot-pressed metal-powder material has been rolled or worked with a protective sheet jacket. Close control of gage thickness in this type of pack rolling is difficult. However, development work on rerolling after jacket removal has shown some improvement in gage tolerances.

Machining of beryllium is different but not difficult. Almost anything that can be machined from aluminum can be machined from beryllium. Fine surface finishes as well as intricate contours, precision-tolerance holes as small as 0.014 in., and thin-wall sections are machined on a routine basis in shops set up for this metal.

Toxicity is a hazard not difficult to avoid. Companies that have worked with beryllium have found that operations can be kept safe by keeping concentrations of the metal in the atmosphere below certain allowable maximums. These limits, while stringent, are not difficult to comply with. After machining, the bulk material or the finished product of beryllium can be handled with no danger of toxic effects.

For developmental or small-production quantities, however, it may not pay to set up stringent house-cleaning and controls. There are several precision machining and fabricating sources that specialize in beryllium metal products. These include facilities at the two producers, The Beryllium Corporation and Brush Beryllium Company, as well as the ones listed below.

Alsca Beryllium Machining Corp	Valley Stream, NY
American Beryllium Co	Sarasota, Fla
American Precision Industries	Buffalo
B G Instruments	Corona, Queens, NY
The Budd Co	Philadelphia
Leemath Inc	Syosset, NY
L A Gauge	Sun Valley, Calif
Marcel Instruments Inc	Monrovia, Calif
Pioneer Astrometallics Corp	Chicago
Speedring Corp	Warren, Mich
Standard Pressed Steel	Jenkintown, Penna
U S Beryllium Co	Inglewood, Calif

For REPRINT of above article, just check 585 on one of the Reader Service cards found in this issue.

EDITOR'S NOTE: For more detailed information on this metal and its unusual oxide see these recent articles:

55% Thread Depth Will Make Beryllium Bolts Practical, Nov 14 '60, p 75—New large-radius thread increases fatigue strength without losing stripping strength; promises improvements in fastener design—beginning with beryllium.

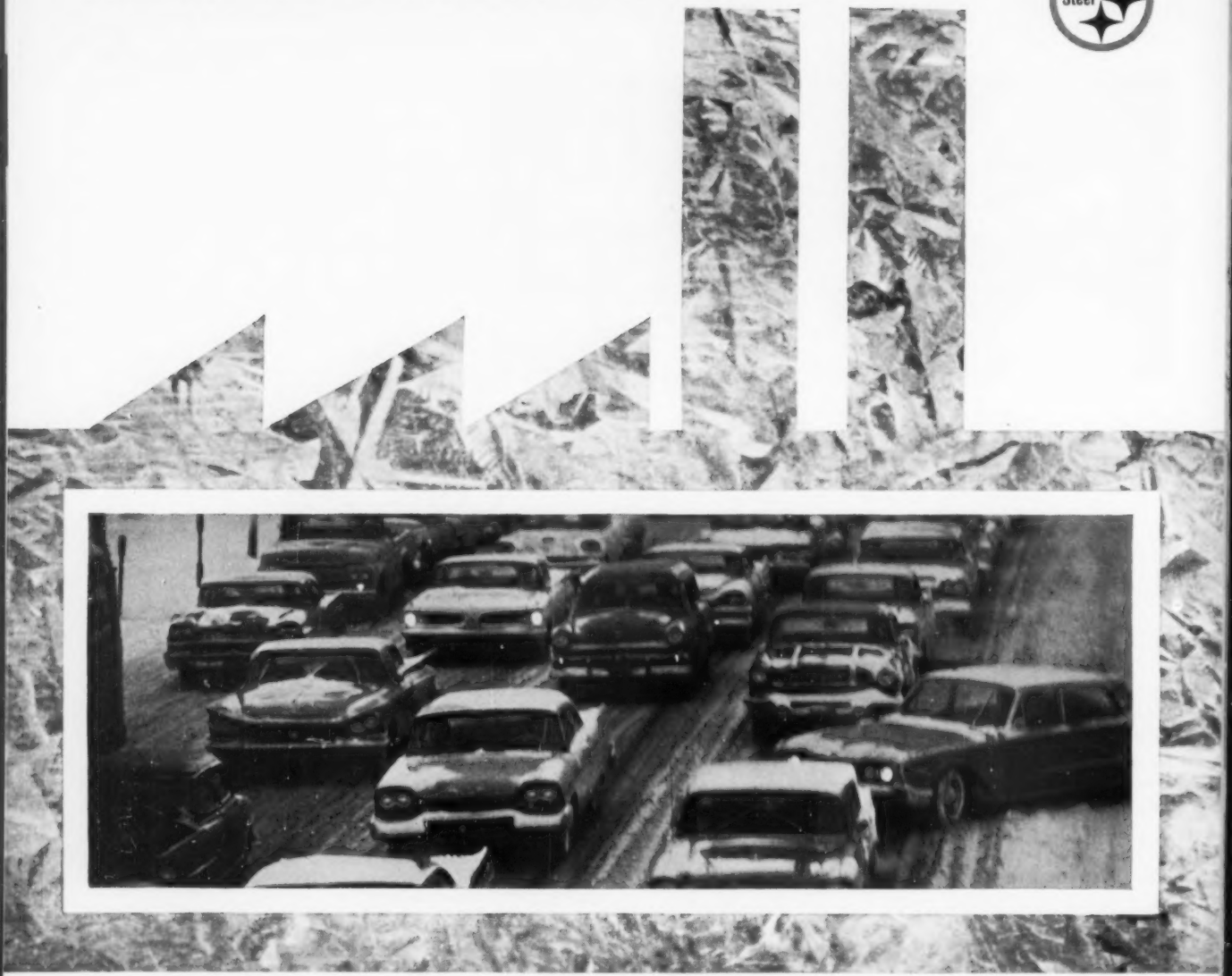
Forming Beryllium Sheet, June 20 '60, p 72—Although this metal is soft, it is also brittle. That's why beryllium sheet must be heated before drawing—one of several precautions necessary when working the metal.

Exotic Metals Seek Employment, Mar 17 '58, p 66—For unusual jobs such as special structural or electrical properties, consider one of these metals.

Designing with Sintered Beryllia—Oct 17 '60, p 65—Comparison with rival ceramics shows that sintered beryllia has outstanding heat conductance, yet insulates against electricity.

—Herbert Kee

The new generation of U.S. autos fends off corrosion . . .



GUARDED BY GALVANIZED STEEL

Use of galvanized steel sheets in the automotive industry has increased by more than 700% since 1954—and more automotive applications are on the way.

As a result of this growing addition to Detroit's diet, both consumers and manufacturers are benefiting. To car owners, every pound of galvanized steel means more complete corrosion protection, added durability and savings in maintenance. To manufacturers, galvanized steel's simplified fabricating procedures bring reduced costs. Head and tail lamp housings, for instance, formerly required five or six steps when zinc plated or painted after stamping. Now they are moved direct from press to assembly line with their tight zinc coatings completely undamaged by fabrication. This also applies to side members, rocker panels, front and rear rails and cross members.

WEIRKOTE, IN PARTICULAR! One of the leading galvanized steels, Weirkote is widely used in the latest model automobiles. To the inherent strength, economy and versatility of steel, Weirkote adds enduring zinc protection via the modern continuous process. As a result, it can be worked to the very limits of the steel base without chipping or peeling. And it assures you long-lasting protection against corrosion. It is manufactured by two National Steel divisions, Weirton Steel Company and Midwest Steel Corporation. Write Weirton Steel Company, Weirton, West Virginia, for further Weirkote details.

MIDWEST STEEL
Portage, Indiana

WEIRTON STEEL
Weirton, West Virginia

divisions of
NATIONAL STEEL CORPORATION

CIRCLE 86 ON READER SERVICE CARD

Wherever two dissimilar metals touch in the presence of moisture, there is chance that one of them will corrode. Here are five steps that will help

STOP GALVANIC CORROSION

FEDERICO STRASSER
Mankowitz & Strasser Ltd
Santiago, Chile

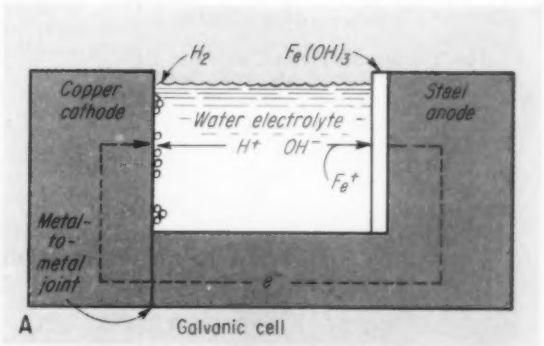
Galvanic corrosion gives you an electrical cell you don't want (A). Like the galvanic cell in an auto battery the requirements are: two dissimilar metals, an electrolyte and a complete circuit. Corrosion is stopped by choosing similar metals; protecting parts from water, the usual electrolyte; or breaking the circuit. Here are five protective steps based on these principles.

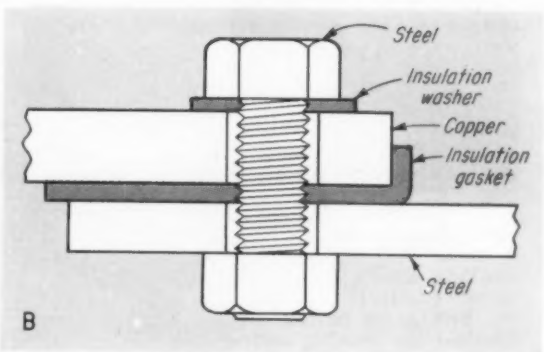
Choosing "nearby" materials

The more anodic the metal, the more readily it dissolves in an electrolyte. The galvanic series, shown in the table, ranks metals by their tendency to dissolve. The farther apart two metals are in the series, the stronger the cell and the more the anode corrrodes. To reduce corrosion, use metals which are near each other in the galvanic series.

GALVANIC SERIES
(in order of decreasing anodic value)

Magnesium	Brass
Magnesium alloys	Copper
Zinc	Stainless steel
Chromium	Bronzes
Aluminum	Monel
Cadmium	Silver
Mild steel, cast and wrought iron	Nickel
Lead-tin solders	Inconel
Lead	Gold
Tin	Platinum
	Titanium





Waterproofing

Keeping the electrolyte out of contact with the metals stops operation of the cell. Waterproofers include: waterproof paint with zinc chromate primer, varnish, lacquer, porcelain enamel and anodizing. To insulate electrical connections, use grease or tape.

Poor waterproofing can be worse than none at all. Small bare spots on the anode concentrate corrosion. For the same reason small anodic fasteners are especially vulnerable.

Insulating

An insulator at the metal-to-metal joint breaks the galvanic circuit. In the example (B), the bolt and the lower plate are both of steel, so the bolt has to have an insulating washer only under the head.

continued, page 89

WEATHER

Fair, Mild

T-J TOMKINS-JOHNSON TRIBUNE

★★★★★ FINAL

THE TOMKINS-JOHNSON CO. • 2425 W. Michigan Ave. • Jackson, Michigan

INCREASED PRODUCTION... CREATES PRICE ADJUSTMENT on T-J Squair Head Cylinders

JACKSON, MICH. JAN. 3 (TP)—"Due to the tremendous initial response and the continuing acceptance and purchase of the new Tomkins-Johnson Squair Head Cylinders, it has been possible to *lower* the basic price," according to T-J personnel. In effecting this price cut, Tomkins-Johnson has again proven that acceptance of a quality product and the inevitable increase in manufacturing volume *CAN* economically justify a price reduction *WITHOUT* jeopardizing quality.

The T-J Squair Head Cylinder, an interchangeable air cylinder for any pneumatic power application, was first introduced by Tomkins-Johnson in 1958. It was an immediate success because of its availability in a wide range of bore sizes and strokes . . . as well as the standard quality features, including the new T-J Super-Cushion for air cylinders.

Other Standard Features

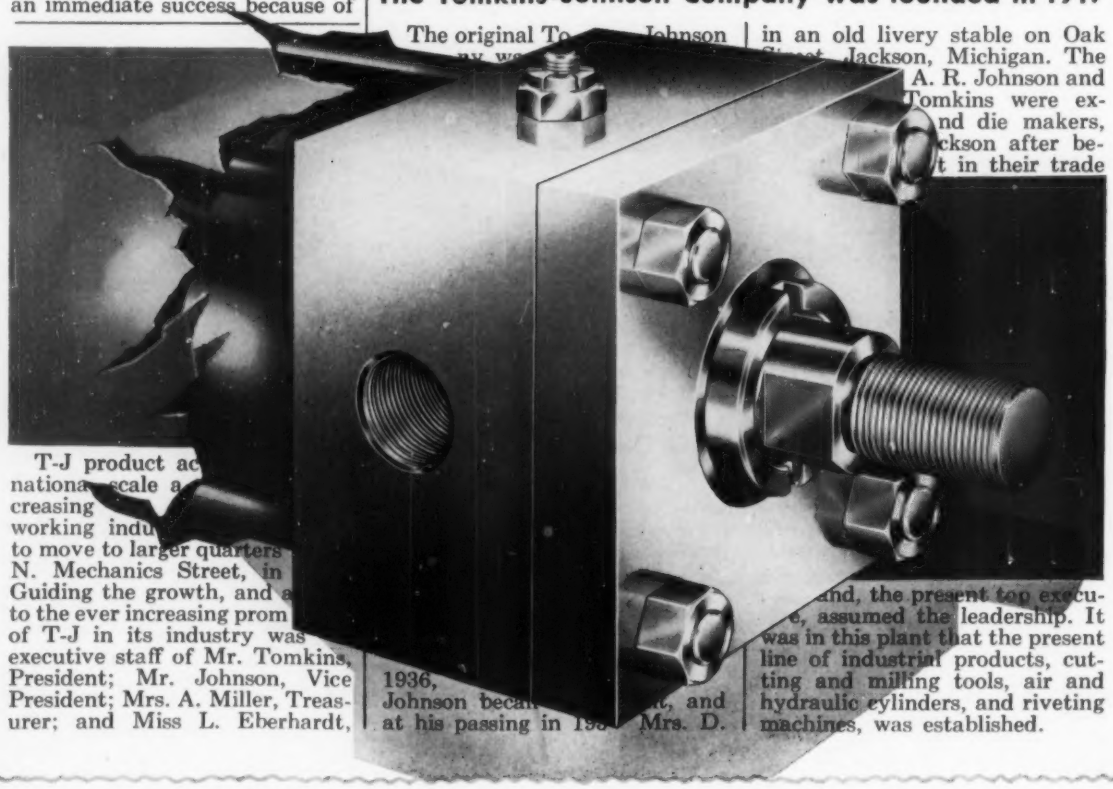
Other standard T-J features that allow the T-J Squair Head Cylinder to retain its high quality comparison over other makes of air cylinders and still give you lower price are; solid steel heads and mounting plates, hard-chrome plated bodies and piston rods, leak-proof cylinder head to body construction, heavy duty, high tensile ground and polished chrome, plated piston rod, and many more . . . STANDARD AT NO EXTRA COST.

Tomkins-Johnson, by virtue of the announced lower cost on its Squair Head Cylinder, wish to thank their customers for their initial acceptance which has been such a contributing factor in this price reduction.

T-J Produces Complete Line

Tomkins-Johnson also produces a complete line of hydraulic and pneumatic cylinders for *EVERY* power drive application . . . including the very popular Spacemaker. If you need further information or complete catalog material, write T-J direct, or request it from your T-J sales representative.

The Tomkins-Johnson Company was founded in 1917



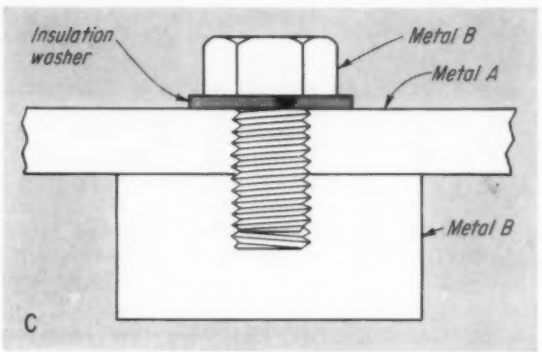
The original To[illegible] Johnson [illegible] in an old livery stable on Oak [illegible] Jackson, Michigan. The [illegible] A. R. Johnson and [illegible] Tomkins were ex[illegible]nd die makers, [illegible]ckson after be[illegible]t in their trade

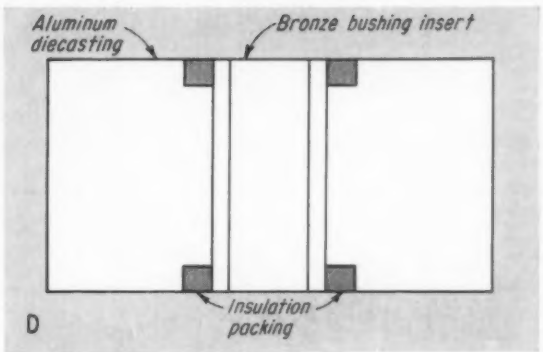
T-J product ac[illegible] nationa[illegible] scale a[illegible] creasing [illegible] working indu[illegible] to move to larger quarters [illegible] N. Mechanics Street, in [illegible] Guiding the growth, and a[illegible] to the ever increasing prom[illegible] of T-J in its industry was [illegible] executive staff of Mr. Tomkins, President; Mr. Johnson, Vice President; Mrs. A. Miller, Treasurer; and Miss L. Eberhardt,

[illegible]nd, the present top execu[illegible]e, assumed the leadership. It was in this plant that the present line of industrial products, cutting and milling tools, air and hydraulic cylinders, and riveting machines, was established.

1936, [illegible] Johnson becam[illegible]t, and at his passing in 19[illegible] Mrs. D.

STOP GALVANIC CORROSION continued

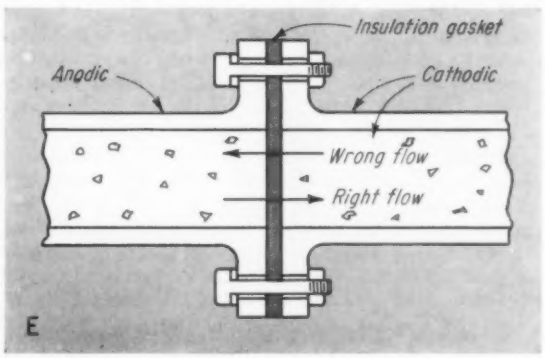




Some insulators are more like moisture hurdles because they insulate only the metal-to-metal joint exposed to moisture. As shown (C) they make it more difficult for moisture to bridge the gap between the metals. This washer also keeps moisture away from the threads.

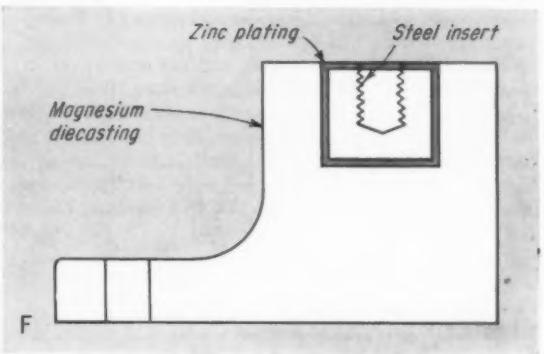
Instead of a gasket or washer, the insulator can be packing or cement pressed into a groove at the joint as with the diecasting insert (D).

Insulating gaskets between lengths of pipe of different metals (E) is not enough. Dissolved and abraded cathodic metal in the liquid will set up galvanic cells as it passes through the anodic section. With flow from anodic to cathodic sections, only the suspended particles corrode.



Dividing potential difference

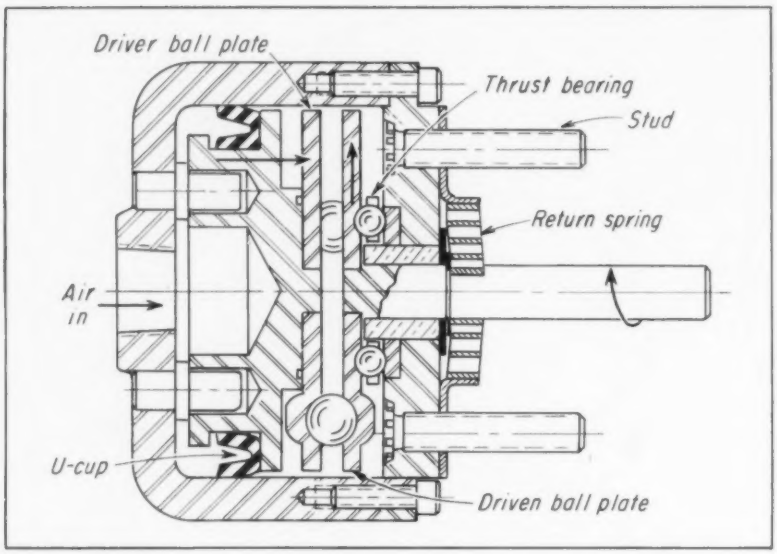
This method separates two metals that are far apart in the galvanic series with a metal that falls between them in the series. The result: two weak cells are substituted for one strong one. In the example (F) the zinc plating falls between steel and magnesium in the galvanic series. Cadmium is a suitable plating for steel inserts in aluminum diecastings.



Protecting with sacrificers

Sacrificial protectors are purposely allowed to corrode so that important parts won't. More anodic than either of the two protected metals, they waste away, requiring periodic replacement. Pumps and condensers use sacrificers because parts are completely immersed in water and metal-to-metal contact is unavoidable. Under such conditions zinc plates or pencils are the only workable solution. Zinc is a good sacrificial protector because it is near the top of the galvanic series and is cheap.

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Air operates rotary actuator . . .
based on a ball-race electrical rotary solenoid. Substitutes graphite-impregnated U-cup piston for solenoid plunger and operates on compressed air instead of electricity. Other working part is rotor plate with shaft extension. Both piston and rotor plate each contain three precision-inclined raceways, which, when assembled face to face, provide a controlled path for three ball bearings. Piston moves in linear direction only, while rotor plate with its shaft extension is restricted to rotary travel. Pressure on piston exerts force on ball bearings, and vector forces resulting from raceways cause rotor plate to turn. Currently available model rotates 90° in 30 to 40 millisec when piston moves axially about $\frac{1}{8}$ in. Piston displacement is approx 0.16 cu in. Weighing 15 oz, unit delivers net torque of 6.5 lb-in. Priced at $42 each in quantities of 1 through 9; $37.50 each for 10 through 24 units; and $31.50 each for 25 through 99 units. Small quantities from stock. **Ledex Inc, 123 Webster St, Dayton 2, Ohio.**

Circle 300 on Reader Service Card

Catalyst-type spray head . . .
controls resin viscosity throughout any reasonable temperature change. Injects catalyst directly into resin stream, converging sprays of resin and catalyst. Makes it possible to spray $\frac{1}{4}$-in.—or more—laminate and roll it down in one operation, rather than roll down each $\frac{1}{8}$-in. pass. Pot-life problem reportedly is eliminated since no catalyst is mixed in with resin. Only one pot is required for resin and smaller pot to contain cobalt-peroxide (MEK) catalyst. They are fed to gun through independent lines and converge only when leaving spray head. Head is basic element for three guns—regular, small and gel coat model. In latter gun, only fluid body and air cap are changed for operation. **Rand Development Corp, 13600 Deise Ave, Cleveland 10.**

Circle 301 on Reader Service Card

Modified polybutadiene . . .
is said to be highly abrasion resistant and will not become brittle even at —85 F. Polymer also has moderate resistance to effects of fuels, solvents and chemicals; top electrical properties and ozone-resistance. **B F Goodrich Chemical Co, 3135 Euclid Ave, Cleveland 15.**

Circle 302 on Reader Service Card

Touching tape turns switch . . .
on and off. Applied to wall or machine housing, tape has two bare electrical conductors attached to it. When finger bridges conductors, feeble current flows through it from one conductor to the other. Switch unit, consisting of control box, 36 ft of tape and silver conductive paint for making splices, can be installed in about 15 min. Flush-mounted model available, and wire, instead of tape, can be supplied. Wall-plug model is $3\frac{3}{4}$ x $6\frac{1}{4}$ x $2\frac{1}{8}$ in. Power requirement is $\frac{1}{4}$ w and expected life, 20 years. Priced at $58. **Gardiner Electronics Co, 2545 E Indian School Rd, Phoenix, Ariz.**

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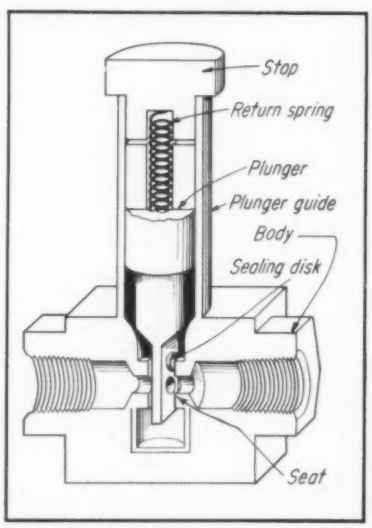

Turbulance, pressure drop are at minimum . . .
in solenoid-operated sliding-gate valve. When solenoid is energized, plunger is pulled up toward stationary core, taking graphite sealing disk along. This clears orifice for straight-through flow. Return is either by spring force or gravity. Valve, which has no organic parts (allowing service over broad temperature and pressure ranges) is available as normally open or normally closed unit, depending upon whether sealing disk is fitted in upper or lower bore of plunger. In normally closed valve with solenoid deenergized, sealing disk is in a position concentric with seats. Pressure from one side of valve pushes it against opposite seat, thereby effecting a seal. Shape of graphite

disk reportedly allows complete seal even if alignment with seats is not perfect. Sizes range from $\frac{1}{2}$ to $\frac{1}{4}$ in., with pressures to 5000 psi. Priced from $8 to $15 (higher with ceramic disks). Delivery in 10 to 12 wk. **Polymet Co, Box 321, Orange, NJ.**

Circle 304 on Reader Service Card

Cadmium sulphide area at 45° angle . . .

makes 0.63-in.-dia cell both top and side-sensitive. Hermetically sealed, all-glass unit with pigtail leads can be used for flame control, on-off switching, relays, automatic counting, and level and density control. Max dissipation is 250 mw; average cell current, 10 ma. From stock at $1 to $2, depending upon quantity. **Amperex Electronic Corp, Semiconductor & Special Purpose Tube Div, 230 Duffy Ave, Hicksville, LI, NY.**

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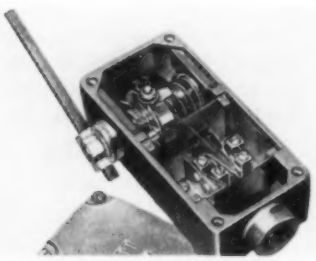

Heavy-duty limit switch . . .

operates in either direction with 160° overtravel on ball bearings. DPST unit has one pole normally open, one normally closed. External arm is adjustable to 30 positions without removing nut, and arm holder provides for $\frac{1}{4}$-in. key stock. Measures $5\frac{1}{2}$ x $2\frac{1}{16}$ x $2\frac{3}{8}$ in. **Edon Industrial Products, 4412 Fernlee, Royal Oak, Mich.**

Circle 306 on Reader Service Card

Flexible control cable . . .

consists of helix-wrapped wire strands passed through rigid tubing, saving weight and providing single path from input to output. Tension and compression forces are reported to be accurately transmitted around bends and between planes without pulleys or linkages. Outer wrap or helix wire can be meshed with hobbed gear to convert cable's linear motion to rotary motion through gear. Cable is available in stainless or carbon steel; fittings in stainless steel or aluminum. **Eanco Inc, 2701 N Broad St, Philadelphia.**

Circle 307 on Reader Service Card

Variable-speed pulleys . . .

rated 20 to 25 hp at 1750 rpm and 10 to 15 hp at 1150 rpm give instantly variable ratios up to 3:1. Curved faces maintain full belt contact at all speeds and pitch diameters. Each face is independently actuated by own spring, allowing equal and simultaneous movement of both halves for constant belt alignment. Standard bores are $1\frac{1}{4}$, $1\frac{3}{8}$, $1\frac{5}{8}$ and $1\frac{7}{8}$ in. with $3\frac{3}{4}$-in. bore length. Motor travel for full range is $6\frac{3}{4}$ in. Pitch diameter is 13.1 in. max and 4.35 in. min. Units are dynamically balanced to 0.02 oz-in. **Lovejoy Flexible Coupling Co, 4856 W Lake St, Chicago.**

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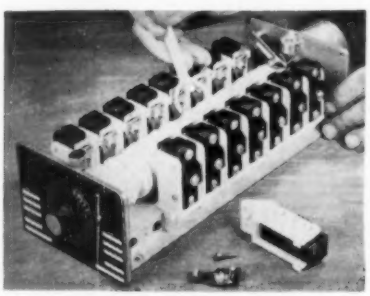
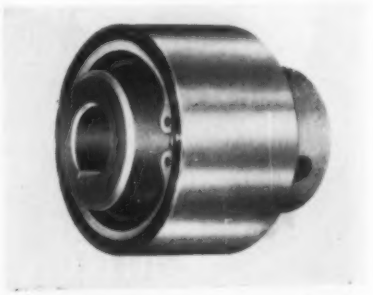


Cycling timer . . .

provides timed-sequence control of up to 20 independent load circuits. Allows cycle speeds from 1 sec to 11 days. On and off points are independently adjustable for each circuit from 2 to 98% of full cycle time. Timing accuracy is stated within $\pm\frac{1}{2}$ of 1% of full cycle time at operating points of each circuit. Has vernier-type setting dial and adjustable split cams for each load switch. SPDT switches are rated 10 amp at 115 v non-inductive. Motors are available for all standard voltages at 50 or 60 cps, 115 v at 400 cps, and 6 to 28 v dc. **Electro-mechanical Div, Cramer Controls Corp, Centerbrook, Conn.**

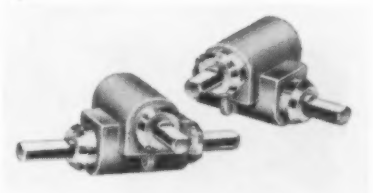
Circle 309 on Reader Service Card



Overload-protector coupling

for $\frac{3}{8}$ to $1\frac{1}{2}$-in.-dia motor and machine shafts, can be preset to disengage at any torque setting from $\frac{1}{2}$ to 60 ft-lb. Remains for unlimited time in disengaged position without overheating or binding. Automatically reengages in same position when overload is corrected and motor is operated at low rpm or turned off and started again. Warranted for 1 million disconnect-reconnect cycles or six months, whichever comes first. **Helland Inc, Navarre, Minn.**

Circle 310 on Reader Service Card



T- and right-angle drives . . .

have $\frac{1}{4}$-in.-dia shafts cut to $\frac{1}{16}$-in. flat to provide strong attachment for coupling ends. Ultimate static torque capacity is 25 lb-in. with backlash of 6°. Available gear ratios are 1:1, 1:2 and 2:1. T-angle drives weighs 4 oz and right-angle unit, $3\frac{1}{2}$ oz. **F W Stewart Corp, 4311-13 Ravenswood Ave, Chicago 13.**

Circle 311 on Reader Service Card

Photoelectric tape reader . . .

uses chopped reflected light to attain improved ratio of signal-to-noise in reading more translucent tapes. Light chopper wheel and ac-coupled amplifiers are said to provide great stability since ac-amplifier drift characteristics top that of dc amplifiers. Unit reads $\frac{1}{16}$, $\frac{7}{8}$ or 1 in. wide tapes and up to eight channels and sprockets of strip or continuous-loop tape. Speed selection includes 10, 30, 75 and 100 ips, at a rate of up to 1000 characters per sec. Takes 3 millisec from dead stop until tape

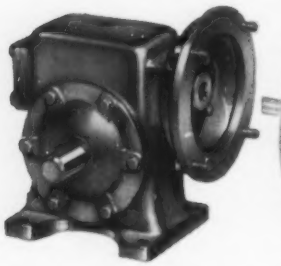
continued on page 93

956

different
motorized
speed reducers

available from stock

Yes! 956 different combinations of Perfection Motorized Worm Gear Speed Reducers are available for immediate delivery, *from stock.* Ratios range from 5 to 1 to 60 to 1, in capacities from 1/6 H.P. to 5 H.P. Perfection "C" Flange Reducers may be ordered complete with motor or without motor, to be used with a motor *of your own choice.*



Flanged motor reducers offer the maximum in compactness, rigidity and adaptability. Through the use of standard NEMA face mounted motors, complete interchangeability between motors is provided. Motor maintenance is possible without disturbing the drive and reducer. Motor assembly is fast and positive with no alignment problems.

Write for your free copy of our new 28 page catalog containing illustrations, charts and tables to help you choose the right Reducer for your particular application. Ask for Bulletin No. M-140.

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AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY, HARVEY, ILLINOIS

WHAT PRODUCT OF YOURS—

can be improved with

MOLDED FIBER GLASS?

In nearly every industry there is a product which can be made better with MOLDED FIBER GLASS — the modern basic material!

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- rust and corrosion resistant
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- heat resistant; impact resistant.

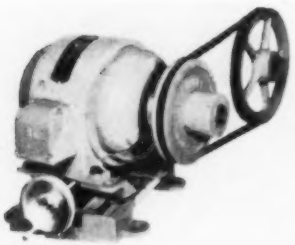
You can improve present products, design new ones, with longer life and greater economy with MOLDED FIBER GLASS. Write for free catalog.

MOLDED FIBER GLASS COMPANY

4423 Benefit Avenue • Ashtabula, Ohio

is at max speed. Unit stops tape in less than 1 millisec and can start-stop on every character up to 100 characters per sec. Output voltage level on a mark is 12 v negative. Operates on 115 v, 60 c. **Omnitronics Inc, 511 Broad St, Philadelphia 23.**

Circle 312 on Reader Service Card



Adjustable motor bases . . .

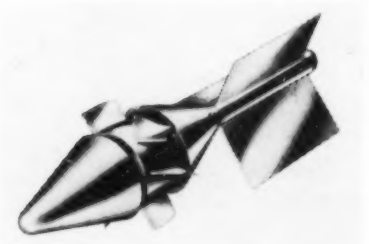
are used with spring-loaded sheaves to provide complete drives for low-speed applications in ¾ to 10-hp capacities. Can be placed in angular position to maintain proper belt alignment and prolong belt life. Speed variation is accomplished by handwheel control, but remote control can be provided. **Speed Selector Inc, PO Box 312, Chagrin Falls, Ohio.**

Circle 313 on Reader Service Card

High-temperature bearing . . .

operating at up to 1000 F, combines corrosion-resistance with a hardness of R_c50. Does not require sealing from temperature or corrosion. Described as deep groove, full compliment, no loading slot bearing, it has 1⅛-in. OD and ½-in. bore. **Industrial Tectonics Inc, Bearing Div, 18301 Santa Fe Ave, Compton, Calif.**

Circle 314 on Reader Service Card



Transducer's pressure feedback

between downstream and upstream systems keeps rotor hydrodynamically balanced between support and cone without use of thrust bearings. Rotor turns on a journal bearing, mounted on a cantilevered shaft. Suitable for any liquid or gas, the turbine-type flowmeter operates within

continued on page 96

PARCO PROBLEM PROBERS ???... FAILURE-PROOF BONDING

!!! If your product design includes components where rubber is bonded to metal, how can you be sure that these bonds are failure-proof? There is no known method for testing a bonded joint except by testing to destruction. Failure-proof bonding must be accomplished during component production, not ascertained by subsequent tests. ◯ This is where Parco's research, process control, scientifically designed production equipment, exacting production techniques and experienced personnel pay huge dividends in bonded joint quality and dependability. ◯ Parco laboratories have thoroughly researched the bonding of rubber to metal and have developed precise and scientific process controls which assure consistent, fail-proof results. Bonding is accomplished with shop equipment *specifically designed for this specialized purpose*, and by Parco operators with years of experience in bonding. ◯ Consult with Parco engineers regarding rubber-to-metal bonded joints which are stronger than the rubber itself.

Send for your latest Parco Slide Rule

Parco

Plastic and Rubber Products Company
2100 Hyde Park Boulevard
Los Angeles 47, California

Plastic and Rubber Products Company
2100 Hyde Park Blvd. • Los Angeles 47, Calif.
Please send the Parco O-Ring Data Chart to:

NAME_____
COMPANY_____
BUSINESS ADDRESS_____
CITY_____
ZONE____ STATE_____

CIRCLE 93 ON READER SERVICE CARD
CIRCLE 94 ON READER SERVICE CARD→

Now! Make any pushbutton station you want with new, completely versatile Cutler-Hammer oiltight pushbuttons

Choose from a complete line of operators, get greater circuit flexibility than with any other make

To meet today's need for a broad range of oiltight pushbuttons, Cutler-Hammer gives you a new versatile line.

You can get these rugged proved pushbuttons in one hole or base mounting, six bright colors. More than thirty different circuit arrangements are available plus hundreds of varieties of stations in standard arrangements of up to 25 elements. And you can get up to 8 circuits on one pushbutton. The flexible oil resistant diaphragm behind the button is designed to stay soft and pliable permanently.

With Cutler-Hammer pushbuttons you can get more control in less space, too, because they use 40% less behind the panel space than the next smallest unit.

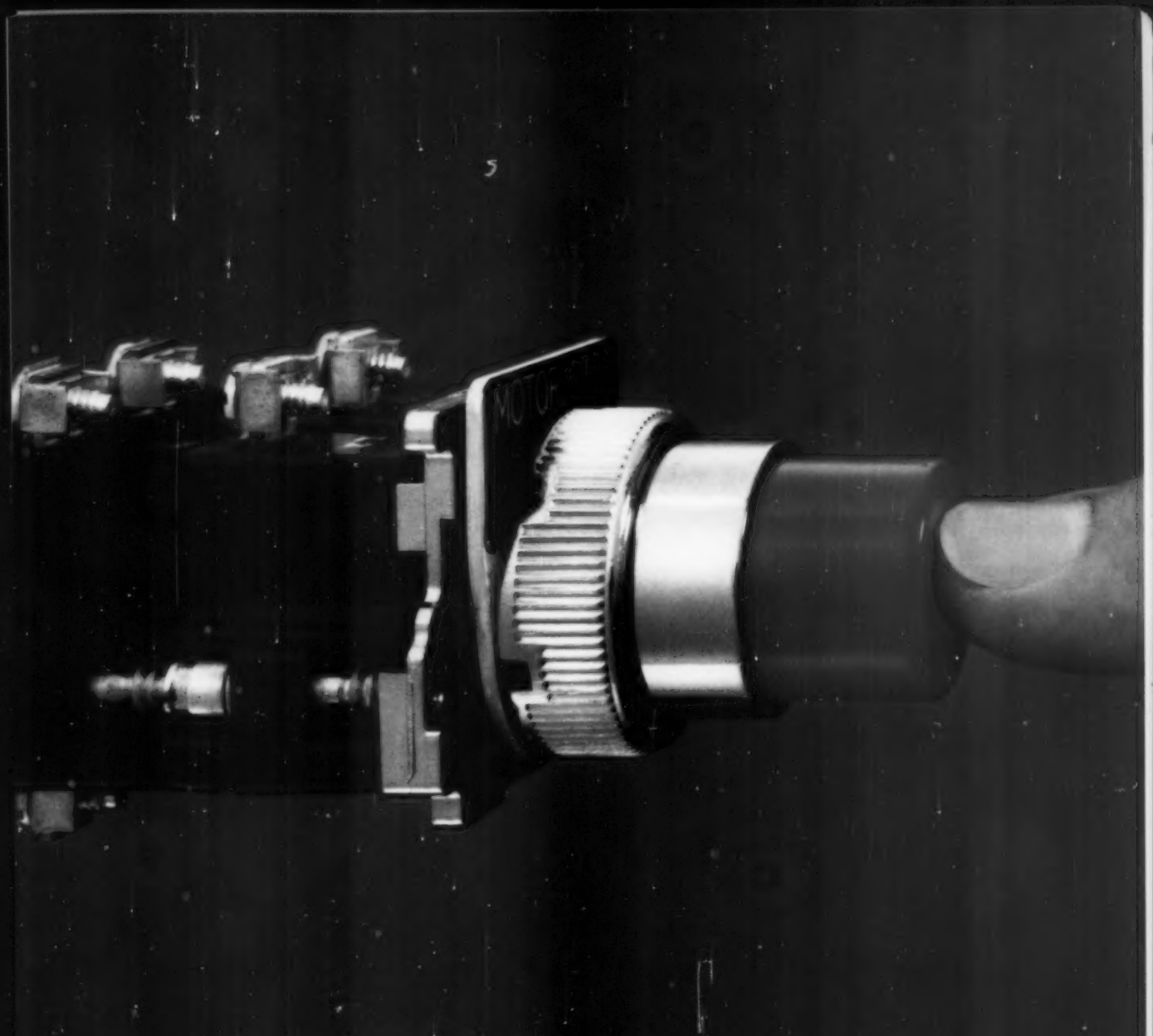
Get all the facts by sending for the colorful brochure, "MASTER DESIGN" which tells you all about the Cutler-Hammer line. Ask for Pub. LO-104.

What's new at Cutler-Hammer? You can see the newness in the products coming from Cutler-Hammer, like the new smaller pushbuttons; in the new manufacturing facilities; in the new engineering ideas. All to give you better service today and in the future. Contact the nearest Cutler-Hammer sales office or your Cutler-Hammer distributor.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.



NEW ILLUMINATED PUSHBUTTON. Newest addition to the versatile line.

YOU CAN GET ALL THESE TYPES OF CONTROL UNITS

LEVER

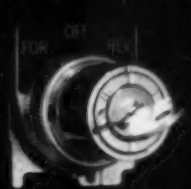
MUSHROOM

LONG

ROTO PUSH

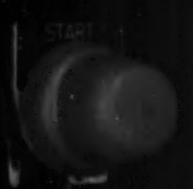
STANDARD

RESISTOR LIGHT



KEY

TRANSFORMER LIGHT

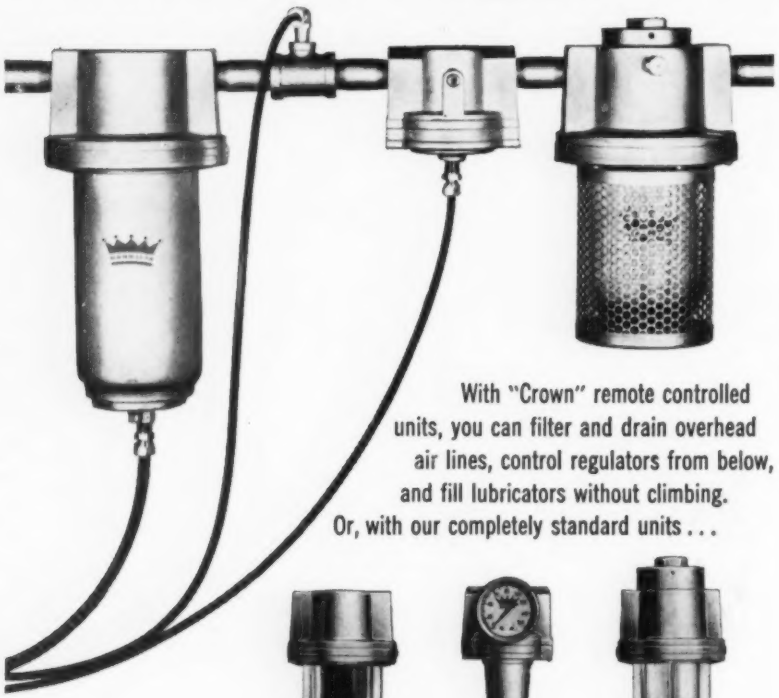


GUARDED

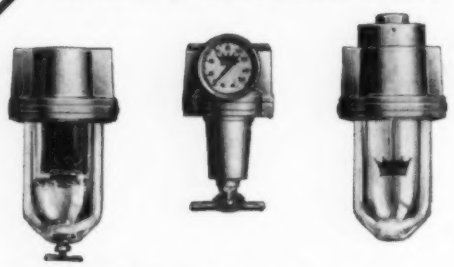
PRETEST LIGHT

HANNIFIN *Crown*

delivers air the way you want it!

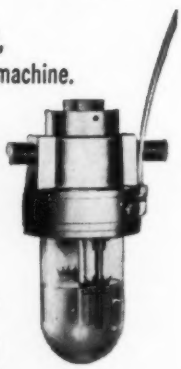


With "Crown" remote controlled units, you can filter and drain overhead air lines, control regulators from below, and fill lubricators without climbing. Or, with our completely standard units . . .



. . . you can provide just the right amount of filtered, regulated and/or lubricated air right at your machine.

NEW! **PULSE-LUBE . . . for off-beat air flow**



If air flow is uphill or light or so infrequent that air-borne lubrication won't solve your problem, you can deliver oil just where you need it, in the exact amount you need, through a tiny flexible tube with new "Crown" Pulse-Lube . . .

All these "Crown" developments are detailed and described in a new, comprehensive "Crown" catalog (our Bulletin 0400-B1). We'll be happy to send you one.

PARKER HANNIFIN CORPORATION

HANNIFIN COMPANY
A DIVISION
525 South Wolf Road • Des Plaines, Illinois
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

3071-PH

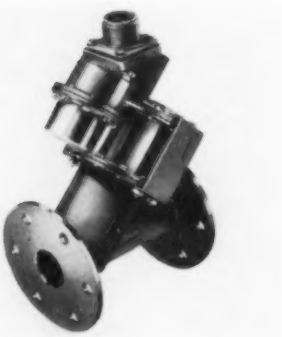
temperature range of —455 to 500 F. Smallest of 14 models has nominal flow range of 0.75 to 7.5 gpm; largest, 250 to 11,000 gpm. Frequency at max flow rate is 500 cps. Max line pressure is 5000 psi for stainless steel and 2500 psi for anodized aluminum. **Francisco Engineering Co, 23987 Ventura Blvd, Calabasas, Calif.**

Circle 315 on Reader Service Card

Adhesive for rigid and unsupported vinyls . . .

is said to develop a high initial bond strength that increases with age. A modified acrylonitrile rubber-base cement, it can be heat- or room-temperature-cured, has long color life and can be used under wide temperature and humidity range. When dry, it remains tack-free and is oil-resistant. Also suitable for bonding steel, tinplate, leather, wood, glass, ceramics and paper. **UBS Chemical Co, 491 Main St, Cambridge, Mass.**

Circle 316 on Reader Service Card



Hi-temp poppet valve . . .

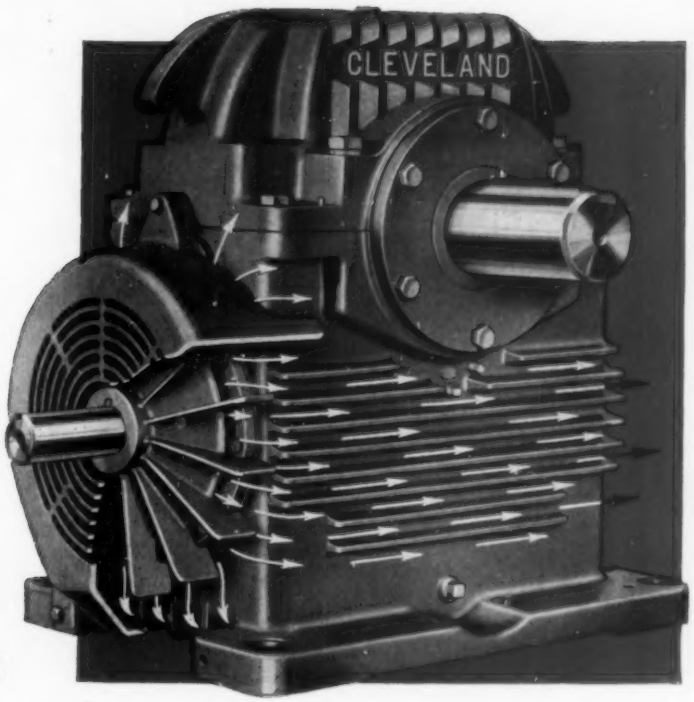
operating at 950 F, is suitable for max operating pressure of 265 psig (1-in. unit). Internal leakage is 0.04 lb/min at 265 psig and 540 F. Solenoid can be incorporated for operation at duct temperatures up to 1000 F and 800 F ambient or higher. The 1-in. unit weighs 1.85 lb. **Aircraft & Missile Products Div, Barber-Colman Co, Rockford, Ill.**

Circle 317 on Reader Service Card

High-strength steel sheet . . .

produced in three grades, allows up to 25% lighter sections without loss of strength. One grade has min tensile strength of 70,000 psi, min yield point of 50,000 psi and elongation in 2 in., 22%. A second grade is produced for specific forming problems. Third grade is for jobs requiring higher load-bearing capacity and deadweight reduction. It is produced to

continued on page 99



Fan cooling for Increased HP Capacity is Not New... *to users of Cleveland Speed Reducers*

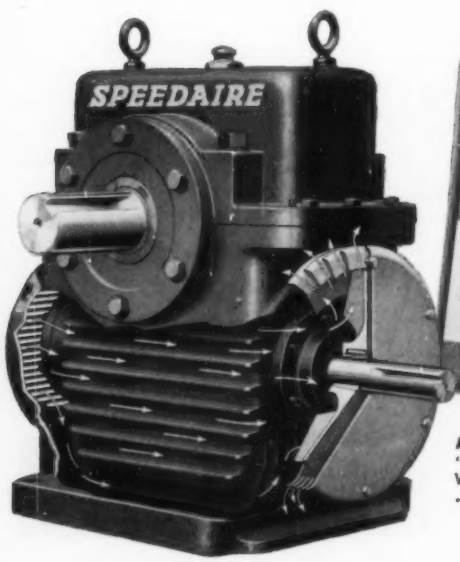
As far back as 1944, Cleveland Speedaire Worm Gear Reducers (shown in both the announcement ad and cutaway photo below) were providing industry twice the load carrying capacity then available from standard worm gear units of equal frame size. Even then, it was *fan cooling* that did the trick—because fan cooling was and still is the most practical method of heat dissipation.

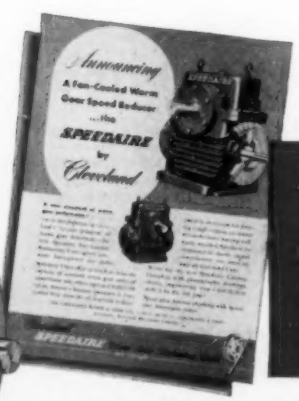
On the new, higher horsepower Cleveland's (shown in top cutaway photo), a small, specially designed fan—equally effective in either direction of rotation—is located on the worm shaft's input side. Fan size and design permit a smooth, more effective flow of air beneath, above, and around all sides of the reducer.

Mounting the cooling fan on the WORM shaft input end is a very definite Cleveland advantage for when the fan is mounted on the *opposite* side, a second oil seal is needed. This results in additional friction loss due to seal drag—and is another point where oil leakage could occur.

Remember, it was Cleveland design engineers who pioneered both fan cooling and centrifugal casting of bronze gears—and after sixteen years of rugged field usage in all types of industrial plants, have now incorporated these features in all units (from 3 to 12-inch centers) of the new standard Cleveland Speed Reducer line.

Get the story of these new speed reducers from your Cleveland representative, or write today for free 36-page illustrated Bulletin No. 410 that contains complete engineering information. Either way, you will get the answer to improved speed transmission—at savings of 50% or more on per horsepower cost!





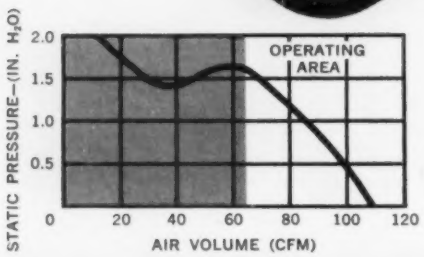
A 1944 CLEVELAND AD
"Announcing A Fan-Cooled Worm Gear Speed Reducer ... SPEEDAIRE."

CLEVELAND
Worm Gear
Speed Reducers

Cleveland Worm & Gear Division
Eaton Manufacturing Company
3279 East 80th Street • Cleveland 4, Ohio

CIRCLE 97 ON READER SERVICE CARD 97

3" dia. x 3¼" long, 16 ounces



NEW VANEAXIAL

AC/DC UNIVERSAL BLOWER

Globe's VAX-3-GN Universal Blower gives you 110 cfm. free air, with a design point of 68 cfm. at 1.5" H_2O—on **either** 115 v.d.c. or 115 v.a.c., 60 cycle power. Other voltages can be supplied. Nominal speed is 14,000 rpm.

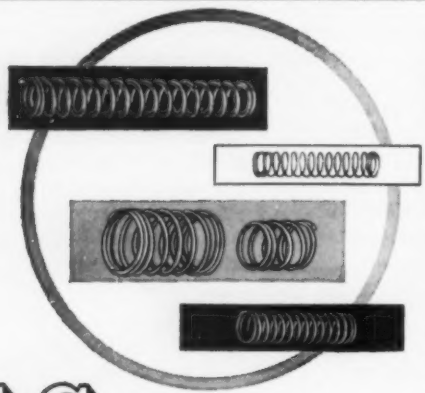
You can standardize on this extremely versatile blower for ground support and commercial electronic cooling. It's designed to meet MIL specs, having passed shock and vibration per MIL-E-5272. Production tooling makes this blower economical. Prototypes can be in your hands tomorrow (telephone BA-2-3741 for part no. 19A908); production orders normally delivered in a short time.

Rugged mechanical protection is provided by the black anodized aluminum housing and propeller. Mount by clamping to servo ring at either end. Nominal life exceeds 1000 hours. Max. current is 0.47 amps at free air delivery. Request Bulletin GNB from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE

GLOBE INDUSTRIES, INC.

CIRCLE 204 ON READER SERVICE CARD



MICRO-PROCESSED FOR EXTRA RELIABILITY!

Micro-processed I-S beryllium copper compression springs, being non-magnetic and corrosion resistant, and having good electrical conductivity, are exceptionally well suited for critical applications. Undesirable internal stresses are removed during heat treatment resulting in better current carrying capacity, lower drift and higher endurance life. The exclusive process by which I-S Micro-processed springs are manufactured make it possible to fulfill the most exacting specifications in all respects. Unusually close tolerances are held on diameters ranging from .020" to 1.00" ID. Laboratory certified beryllium copper wire in standard B & S gages from .0025" to .072" with a tensile strength of over 200,000 psi is used in producing I-S Micro-processed springs. Close quality control is maintained to insure correct spring rate and load requirements.

I-S Beryllium Copper Springs

Call or write for I-S catalog including data on:

- COMPRESSION SPRINGS
- FLAT SPRINGS
- STRIP SPRINGS
- CONTACT RINGS
- CONTACT STRIPS
- SCREW MACHINE PRODUCTS

FOR FURTHER INFORMATION SEE OUR CATALOG IN SWEET'S

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CIRCLE 98 ON READER SERVICE CARD

CIRCLE 205 ON READER SERVICE CARD

min yields of 45,000, 50,000, 55,000 and 60,000 psi. Corrosion resistance is 4 to 6 times that of carbon steel of the same thickness. **Pittsburgh Steel Co, Grant Bldg, Pittsburgh 30.**

Circle 318 on Reader Service Card

Adjustable-speed drives . . .

available in ¾ to 7½-hp sizes, consists of dc motors powered by two thyratrons in full-wave circuit. Speed ranges up to 100:1 can be reached. By controlling thyratron tubes with magnetic amplifier, drives will hold rpm within 2 or 3% of set speed under varying loads. Drift with time is $\frac{1}{10}$ or $\frac{2}{10}$% of set speed after warmup. Even from cold start, drift reportedly does not exceed 2%. Standard input voltage is 230 v, 60 c, single phase. **Cleveland Machine Controls Inc, 1155 Brookpark Rd, Cleveland 9.**

Circle 319 on Reader Service Card

O-ring seal fittings . . .

are for leakproof, 6000-psi, water-oil-gas service at temperatures from —20 to 275 F. Available for ¼ to 2½-in. tubes and pipes and in female or male pipe and socket weld configurations. **Kahn & Co Inc, PO Box 516, Hartford 1, Conn.**

Circle 320 on Reader Service Card

Variable-speed drives . . .

have speed ratios up to 10:1 from 4 to 10,000 rpm. Available in ¼, ⅓, ½, ¾ and 1 hp, three and single phases, 60 c. Fluted knob controls, which reportedly turn with 1/7 the effort of similar controls, allow infinite gradations of variable speeds. Can be mounted on or inside driven machine to perform as motor, speed changer, cone pulley or controller and gearbox. The ¼-hp size measures 14½ x 8½ and weighs 63 lb. **US Electrical Motors Inc, PO Box 2058 Terminal Annex, Los Angeles 54, Calif.**

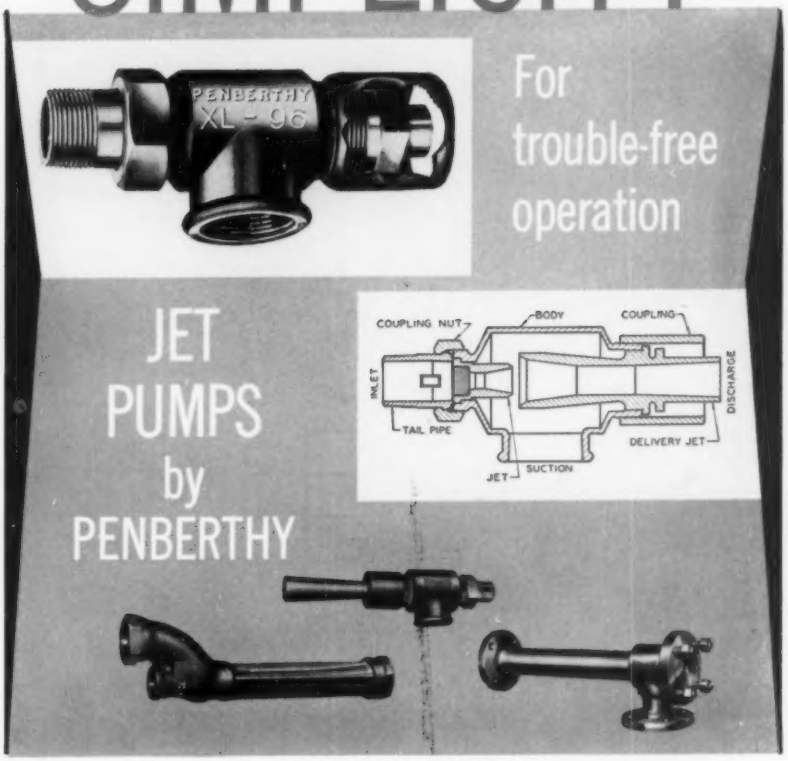
Circle 321 on Reader Service Card

Rotary limit switch . . .

has four circuits, each with a SPDT switch having one normally open and one normally closed contact, electrically separate, and an independently adjustable cam. Switches are rated at 10 amp, 125 v ac and 10 amp, 30 v dc. Twelve ratios from 5:1

continued on page 101

SIMPLICITY



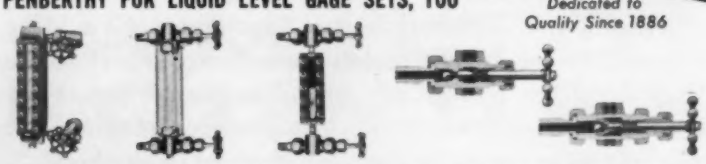
If you have a liquid heating, circulating, aerating, agitating, pumping or blending application (to mention a few), you'll find, chances are, that there just isn't a more economical, efficient, trouble-free device for handling the job than a Penberthy Jet Pump. They cost little to buy, little to install. And maintenance? Practically non-existent, for there are no moving parts, no packing glands, nothing to lubricate.

Penberthy, what's more, as the #1 name in Jet Pumps . . . with almost 70 years' experience in the field . . . offers you the broadest available selection of models, standard or special, steam, air or liquid operated, in a variety of materials. Ask a Penberthy engineer for assistance with your jet pump application.

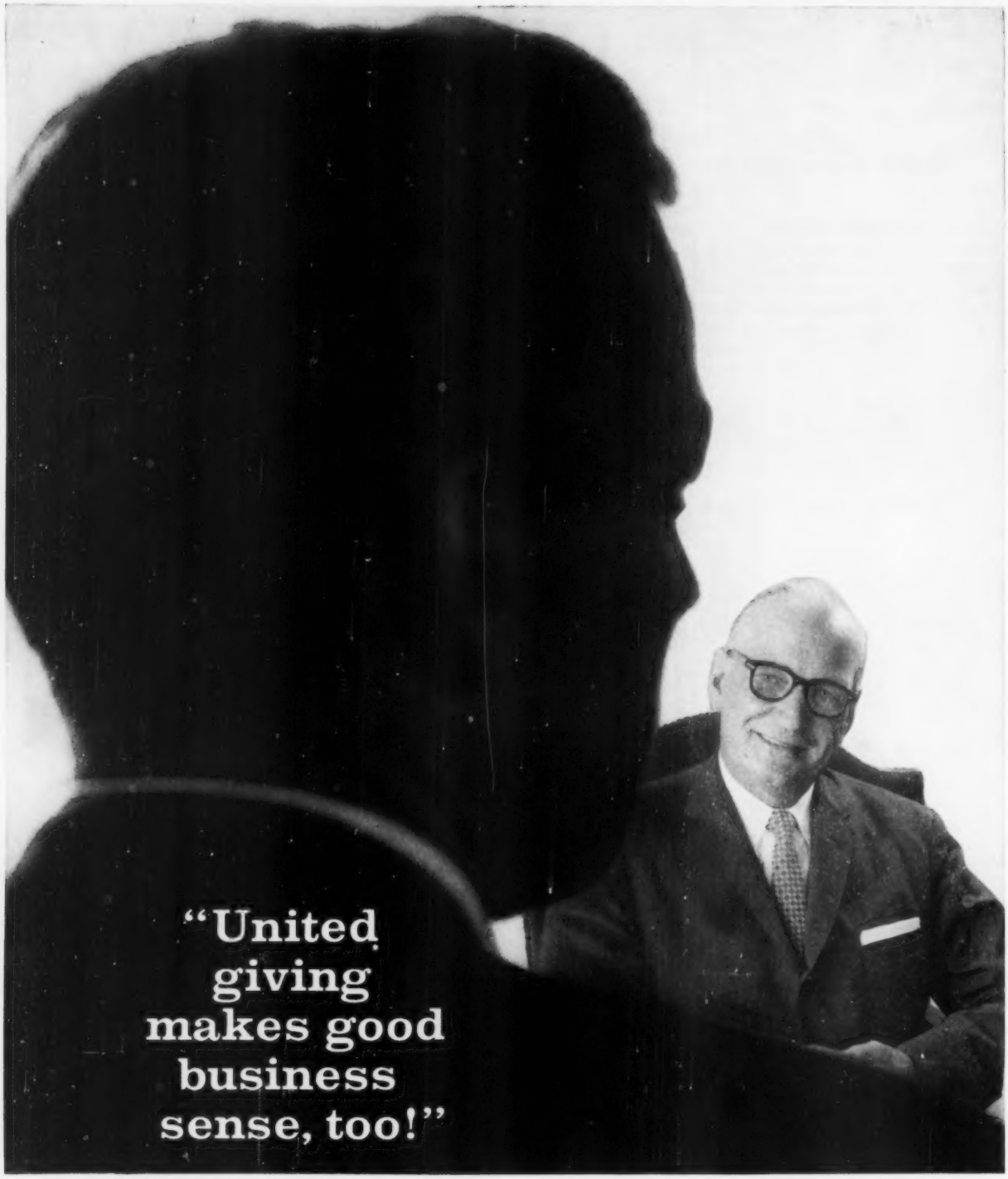
PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
PROPHETSTOWN, ILLINOIS
SALES OFFICE: 2660 E. GRAND BLVD., DETROIT 11, MICH.

PENBERTHY
Dedicated to Quality Since 1886

PENBERTHY FOR LIQUID LEVEL GAGE SETS, TOO



WRITE OR CALL PENBERTHY TODAY FOR COMPLETE INFORMATION



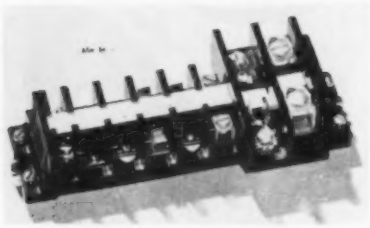
Every business has a vital stake in the welfare of its community. The businesslike way to protect these interests is to support your community The United Way. Your United Fund or Community Chest Campaign takes care of many community needs without the confusion and waste of separate appeals.

Your company can contribute in *three* important ways! ■ Make sure your company makes a generous corporate contribution. It helps protect the welfare of your employees and customers. ■ Help your employees meet their obligations through easy payroll payments. Experience shows this often doubles, even triples, results. ■ Stimulate executive participation in support of your local fund. Such participation helps safeguard the dollar investment made by your company and its employees.

Remember, giving The United Way helps your community *and* your company. **GIVE THE UNITED WAY**

to 1000:1 are offered, along with cam arrangements from 25 to 335° (period for which switch is actuated) in approx 20° steps. Unit is useful where motion is expressed in shaft rotation. **Gemco Electric Co, 25685 W Eight Mile Rd, Detroit 40.**

Circle 322 on Reader Service Card



Terminal boards . . .

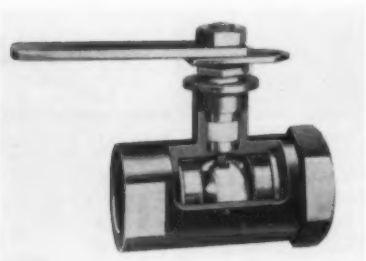
are available in both sectional and 4-, 6- and 12-point types. Latter is rated up to 30 amp, 600 v max and will take up to No. 10 wire. Has screw terminals. Sectional boards are furnished with box, screw, saddle-clamp, quick-connect, and half quick-connect–half saddle-clamp terminals in 25 amp; with 50-amp box terminals; 30-amp fuse blocks and 125-amp box terminals. Available in preassembled forms or in "building block" kits. Terminal blocks are packaged 50 per kit for 25-amp forms; 25 per kit for 50-amp forms; and 1 a kit for fuse block and 125-amp box terminals. **General Purpose Control Dept, General Electric Co, Bloomington, Ill.**

Circle 323 on Reader Service Card

Automatic electric drain . . .

for installation in ¾-in. pipe line, has four adjustable cycle timer settings: once every 2, 3, 4 or 6 hr. Valve opening time can be 2, 5 or 10 sec. Available in all common ac voltages. **S & G Mfg Corp, PO Box 1309, New Orleans 10.**

Circle 324 on Reader Service Card



Ball valve . . .

has adjustable stem seal; self-adjusting ball which seals with flow in either direction; and stem shoulder to prevent ball from being forced downward. Sizes range from ¼ to 2½ in. for pressures to 400-lb water-oil-

continued on page 102

ABRASION RESISTANCE

A CASE IN POINT—Under highly abrasive conditions dust and fly ash collector tubes such as these used to give out in less than a year. Ni-Hard castings were an obvious yet difficult answer because the 38″ length with 5/16″ section was hard to cast. Where others failed Hamilton Foundry succeeded in casting these in production quantities for Western Precipitation Multiclones. The hardness (up to 700 Brinell) and metallurgical structure of Ni-Hard make it one of the most abrasion resistant materials commercially available today. Tubes from Hamilton Foundry Ni-Hard now last more than five times as long as before.

When buying castings, the skill and integrity of Hamilton Foundry is your best insurance that specifications—and delivery schedules—will be met.

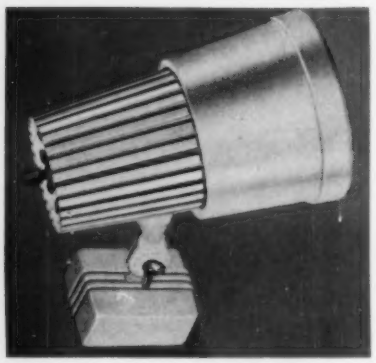
GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY INC.

1551 LINCOLN AVENUE • HAMILTON, OHIO • TWinbrook 5-7491

gas and temperatures to 450 F. Made of bronze, brass, semisteel, carbon steel and 303 or 316 stainless steel with Teflon seats and seals. Available with full round, pipe-size passage to fluids or with restricted passage on request. Homestead Valve Mfg Co, Corapolis, Penna.

Circle 325 on Reader Service Card



Magnetic base on lamp . . .

has 60-lb holding power, although weighing only 10 oz and measuring 2¾ x 1½ x 1 in. Holding power is said to be unaffected by impact, heat, use of storage, and polyvinyl chloride cover is impervious to oil, grease and most industrial solvents. Two lamp styles are available: one which illuminates a wide area and one which provides concentrated light in a localized area. Recarr Inc, 126 N Clinton St, Chicago 6.

Circle 326 on Reader Service Card

Stainless steel tubing valve

can handle liquids and gases at 12,000 psi but is said to be priced for practical use at much lower pressures. Has large port openings with min pressure drop. No threading, swaging, flaring, welding or special tools are required for installation. Available for ⅛, ¼ or ⅜-in. OD tubing. Autoclave Engineers Inc, 2947 W 22nd St, Erie, Penna.

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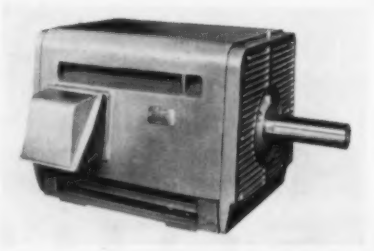

Round stator is placed inside

ac motor's nearly square frame. Said to provide better cooling and use of smaller

it's new
it seals
it saves

it's DELRIN*

Another RB&W development from Delrin plastic, this new threaded plug replaces more expensive metal plugs in many hydraulic and compressor applications.

It not only saves on cost and weight, but also does a better job. Fluid pressure forces mating threads together, creates a still tighter seal, locks threads in place.

Metal-like mechanical properties of Delrin provide excellent strength, dimensional stability, rigidity. Count also on resistance to corrosion and solvents.

Available in ⅛, ¼, ⅜, ½" pipe sizes. Send for samples.

Ask about other parts you would like custom-molded from Delrin, or other thermoplastics, in production quantities.

Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*DuPont trademark

R B&W
116th year

solve your insulation and permeability problems with

SMR

Stoner's SMR has broken through the thermal sealant barrier that has faced the missile and rocket industry for many years.

The varied shapes and forms that this versatile material has taken includes: chamber sealants; liners; insulation for head closures; high temperature insulation; prefabricated proofed sleeves and bladders, as well as other critical applications for rocket components.

SMR is also being used to advantage in plastic molding compounds and pre-preged laminates.

*SMR is a special Silicone Modified Rubber produced by Stoner Rubber Company, Inc.

Photo of Rocket Chamber courtesy of Aerojet-General Corporation

SMR PROVIDES A TOUGH THERMAL LINER AND RELIABLE SEALANT FOR MISSILE AND ROCKET CHAMBERS. This unique rubber has exceptional high bond strength at elevated temperatures.

FREE IDEA CATALOG. Technical information on SMR and other Stoner products in this 24 page catalog will help you solve your rubber problems.

A subsidiary of CARLISLE CORPORATION

STONER RUBBER COMPANY, INC.
10792 Knott Ave. Anaheim, California

overall dimension for any given hp rating. Available from 125 through 300 hp, unit has large air intakes covering each end. Air is drawn in these louvered openings, ducted through rotor and stator and then exhausted at sides. Dripproof enclosure is standard, and either 220, 440 or 550 line voltages are available for 3600-, 1800-, 1200- and 900-rpm operation. **Reliance Electric & Engineering Co, 24701 Euclid Ave, Cleveland 17.**

Circle 328 on Reader Service Card

Resonant-reed relays and oscillators . . .

are available at any frequency from 67 to 1600 cps. Balanced reed and frame configuration is based on tuning-fork principle for frequency stability. Internal linear shock-counting construction makes units insensitive to mounting rigidity, mass or mounting plane. Each has plug-in, 7-pin miniature tube base and measures ¾-in. dia x 2½ in. high (plus pins). Coil resistance is 2 to 5000 ohm. Relay contacts are rated at 250 ma at 12 v dc. Priced at less than $10 each. **Bramco Inc, 4501 Belvidere Ave, Detroit 14.**

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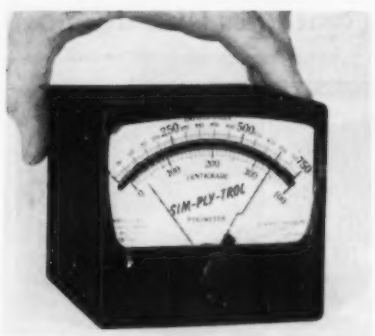

Automatic temperature control

maintains heat within ±1 F despite its small size. Measuring 4¼ x 4 x 5½ in., unit uses a proportioning-type action that minimizes overshoot of set point and produces almost flat temperature curve. Built around locking contact meter-relay, it is available in eight temperature ranges from 300 to 2500 F. Has same 5-amp load relay as comparable larger models. Samples signal from heat source at normal rate of six times a min. Control with single high set point is $185. **Assembly Products Inc, Chesterland, Ohio.**

Circle 330 on Reader Service Card

Gear train servo packages . . .

each with two size 8 rotary elements, are less than 2 in. long and weigh less than 12 oz. One unit, 1 x 1.8 in., accommodates gear ratios up to 1000:1. Weighs 4 to 6 oz, depending upon materials and

continued on page 105

Not a worry in the world

...with *Alnor* PYROTROLLER®

positive temperature control

1. Pyrotroller—an electronic temperature controlling instrument.
2. Pyrotac—a safety excess temperature cut-out or alarm.

Dependable automatic control of temperatures in heat treating furnaces, ovens, plastic moulding, cooking vessels or for any constant temperature requirement. Operates to prevent overheating even with power failure.

The Alnor Flux Gate Sensing Coils

The simple, rugged circuitry in the Pyrotroller has a minimum of components that operate well below their rated capacities. The circuit is not critically tuned and there is no need for repeated adjustment, no shifting of the control point, no need for preselection of the one standard vacuum tube. Sapphire jewel bearings and the very high Alnor standard of precision construction makes the Pyrotroller extremely accurate particularly in the low temperature ranges.

The Alnor Pyrotroller is available in a wide range of temperatures, —100° F. through various maximum temperatures up to 3000° F. The minimum scale span is 400° F. and various ranges can be supplied to meet your particular installation. Write for complete information. Our engineering service is available on special requirements.

Alnor INSTRUMENTS

ALNOR INSTRUMENT CO.

Division of **Illinois Testing Laboratories, Inc.**

Room 527, 420 N. LaSalle St., Chicago 10, Illinois

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CONTROL

New! Space savingest relay you've ever seen: New Cutler-Hammer "Compact 300"

Cutler-Hammer's new, versatile 300 volt 6 amp., industrial control relay is so reliable it's permanently sealed. Bifurcated contacts add even more millions of operations.

So compact you can get 8 circuits in a panel space only 2" wide by 2¾" high. 2, 3, 4, 6, 8 poles with any combination of N.O. or N.C. contacts available. Add new "mechanical memory" latch at any time. Same life as relay. Get full details in PUB. ED-L079-D249.

WHAT'S NEW? ASK...

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.

CIRCLE 207 ON READER SERVICE CARD

The dial thermometer at its best

DISTANT READING

Something much finer in a dial thermometer: finer because it is the bourdon tube type of thermometer at its best... embodies the greater precision and lasting accuracy of the Marsh Pressure Gauge.

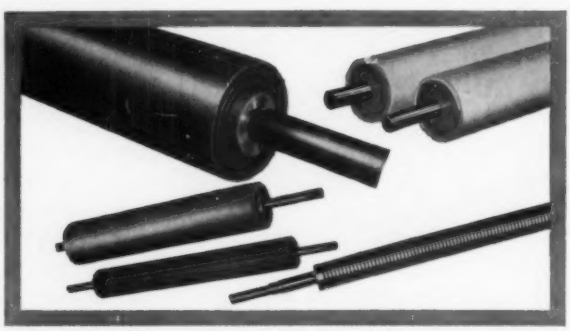
Both vapor tension and gas-filled types are available in either distant reading or rigid stem types. In the broad Marsh line you have a complete selection of temperature ranges, case sizes, styles, and finishes.

RIGID STEM

Ask for the Thermometer Catalog

MARSH

MARSH INSTRUMENT COMPANY, Dept. 39, Skokie, Ill.
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd.
8307 103rd St., Edmonton, Alberta, Canada
Houston Branch Plant, 1121 Rothwell St.
Sect. 15, Houston, Texas



Specify WILBOW *for Custom Built Rubber Covered Rolls*

■ WILBOW is fully equipped to recover, or furnish complete with cores, different types of rolls; for glass machine, meat packers, squeegee, steel mill, feed, tanners, office duplicating, photocopy, paper mill and gypsum board and other special machinery.

Roll coverings can be supplied in natural or synthetic rubber stocks including silicone of various hardnesses, compounded to meet your particular problems, in various finishes, such as Smooth, Crepe, Fluted, Corrugated, Grooved, or with outer covering of duck, or in any other finish to better serve the purpose for which the rolls are intended. Let us know of your roll requirements. Our engineers will be pleased to make recommendations.

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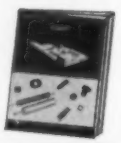
New WILBOW Catalog
It will become your handbook of rubber goods



Wilbow

The WILLIAMS-BOWMAN RUBBER Co.

1955 South 54th Avenue • Cicero 50, Illinois

Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

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CIRCLE 208 ON READER SERVICE CARD

components. Another unit, 1.28 x 1.9 and weighing 6 to 12 oz, accommodates gear ratios up to 4000:1. **Clifton Precision Products Co Inc, 5050 State Rd, Drexel Hill, Penna.**

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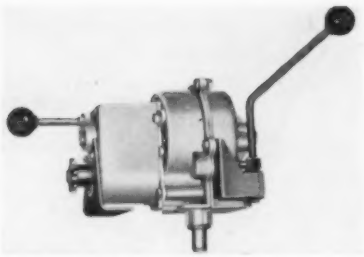

Right-angle reversing transmission . . .

with two speeds forward, reverse and neutral, is originally designed for riding rotary lawn mower engines with capacities up to 5½ hp. Reduction in high speed is 2:1 and in low, 3.4:1. Max input speed is 1800 rpm. Shift lever in right-angle half of transmission controls forward, neutral and reverse. Unit weighs approx 14 lb and can be mounted in any position. **J B Foote Foundry Co, PO Box 2214, Fort Dearborn, Mich.**

Circle 332 on Reader Service Card

Compact calculator . . .

has capacity of 11 digits on keyboard; 8 digits on indicator dial and 15 digits (corresponding to 999 trillion) in answer dial. Cylinder-shape unit measures 2⅞-in. dia x 3⅜ in. high and weighs 12 oz. Does not require external power supply. Tens transfer and reversing lever permits short-cut techniques in multiple operations involving cubes, roots, percentiles, and trignometric functions. **Curta Co, 14435 Cohasset St, Van Nuys, Calif.**

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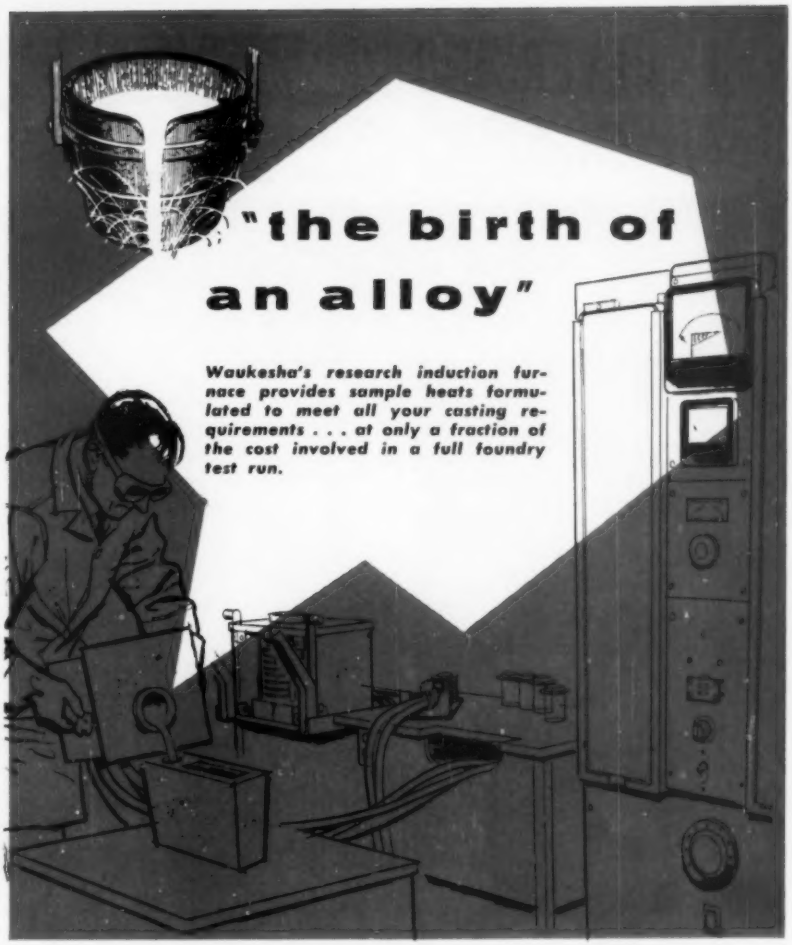
"the birth of an alloy"
Waukesha's research induction furnace provides sample heats formulated to meet all your casting requirements . . . at only a fraction of the cost involved in a full foundry test run.

WAUKESHA CASTINGS

From created alloys . . .

Pressures . . . corrosion-resistance . . . stability under extreme temperature variables . . . increased tensile strengths . . . only castings of created alloys can fulfill all the precise requirements of space-age technology. In less than a decade, Waukesha Foundry Company has created 5 corrosion-resistant non-galling metals.

From blueprint to finished casting, Waukesha follows your precise requirements. Facilities include "Spectrometer" control with each heat, pilot plant facilities, sand, shell and ceramic-type moldings, fully equipped finishing and polishing shop. The metallurgical staff assigned to create the alloy for your product offers over half a century of experience with created metals.

Where precision engineered castings are an absolute requirement, call on Waukesha.

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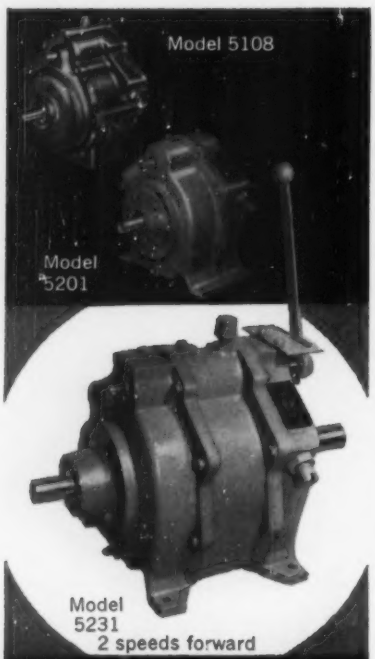
Manufacturers of corrosion-resistant castings, inclusive of non-galling alloys, Stainless Steel, Waukesha Metal, Monel, Pure Nickel, Inconel, Ni-Resist, plus special Nickel-Chromium Alloys for specific applications.

S-N REVERSING TRANSMISSIONS

5 models 8 and 28 h.p. with power packed versatility



S-N Reversing Transmissions are performance proven, space-saving single units which reverse under full load. Adaptable to the design or redesign of a wide variety of industrial equipment. For technical data write The Snow-Nabstedt Gear Corp., Hamden, Conn.

SPECIFICATIONS

Model No.		5231	5201	5108
Reduction Forward		1.97:1 3.34:1	3.16:1	3.75:1
Ratio Reverse		3.37:1	3.16:1	3.75:1
Power Up To		28 HP	28 HP	8 HP
Max. Input Torque in. lbs.		1000	1000	320
Max. Input Speed RPM		2400	2400	2400
Dimensions	Long	15 11/16"	11½"	9 1/16"
	Wide	14"	13½"	10"
	High	14¼"	14¼"	10½"

SNOW-NABSTEDT
Industrial Division
Transmission Engineers
For Over Half a Century

DESIGN LITERATURE

Ideas, Inertia and Achievement

Report by F B Turck of a study sponsored by the ASME. American Society of Mechanical Engineers, 29 W 39th St, NYC 18. 6 x 9, 183 pp. $5.

History is replete with the tales of children who turned against their fathers. This report is another example. This survey of "selected corporations, scientific institutions and individuals devoted to shortening the time lag between original scientific discovery and engineering application" proves fairly conclusively, at least to this reviewer, that the time lag is a minor problem. When there is a need for science, it is used; when there is a crisis, it is used faster. Again and again, the approximately 100 replies point out that the time lag is a straw man, that there are many more real problems—like classification and communication. One respondent tells how he must go overseas to get reports on American developments that are classified here, another suggests that there should be better technical papers, better edited and better selected. But the report hangs doggedly to its unsupported conclusion, as if its compilers weren't paying attention.

The book has its values as an exhibition of current opinion on a variety of problems and the ideas of informed men for their solution. The letters have been thoughtfully written. It would serve as an excellent basis for determining what the present-day problems in communication of technological information really are and proper directions for future study. But these studies should be undertaken with an open-mindedness which we seem to be so often lacking. The studies should be inductive, not deductive; we have too often the tendency to try to make events support a preconceived conclusion.

The first part of the volume is simply a collection of extracts of what are obviously excellent letters. It has no index and the organization is poor, making reference difficult. Divisions include the problem, communications, management, the Soviet system (!), corporate planning, the institute approach. The last group of reports includes several foreign ones, and the last three groups are longer reports.

—EJT

Induction Heating: Coil and System Design

P G SIMPSON. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9, 308 pp. $11.50.

The practical part of this book tells how to get the most from induction heating. It describes low-frequency heating, metal-joining and annealing at high frequencies and how to surface-harden steel to accurate case depths. Coil designs are shown for typical applications.

In addition, the book gives information on heat flow in induction-heated parts, selection of frequency for different part sizes and applications and choice of automatic controls. The curves and nomograms included are helpful when solving design problems related to induction heating.

Ultrasonic Welding

ARTHUR L PHILLIPS. American Welding Society, 33 W 39th St, New York 18. 6 x 9, 38 pp. $1.50.

Instead of melting metal with an electric current, this process welds by focusing ultrasonic energy at the joint. The vibration disrupts surface films and causes grains to grow between the two pieces of metal. This is essentially why ultrasonic welding has broader capabilities than that of older methods. Spotwelds now can be spaced for optimum strength rather than for weld-current distribution. Also more-dissimilar metal combinations can be made because there is no melting to form brittle compounds.

Concise but complete, this excerpt from the Welding Handbook is informative and well worth its price.

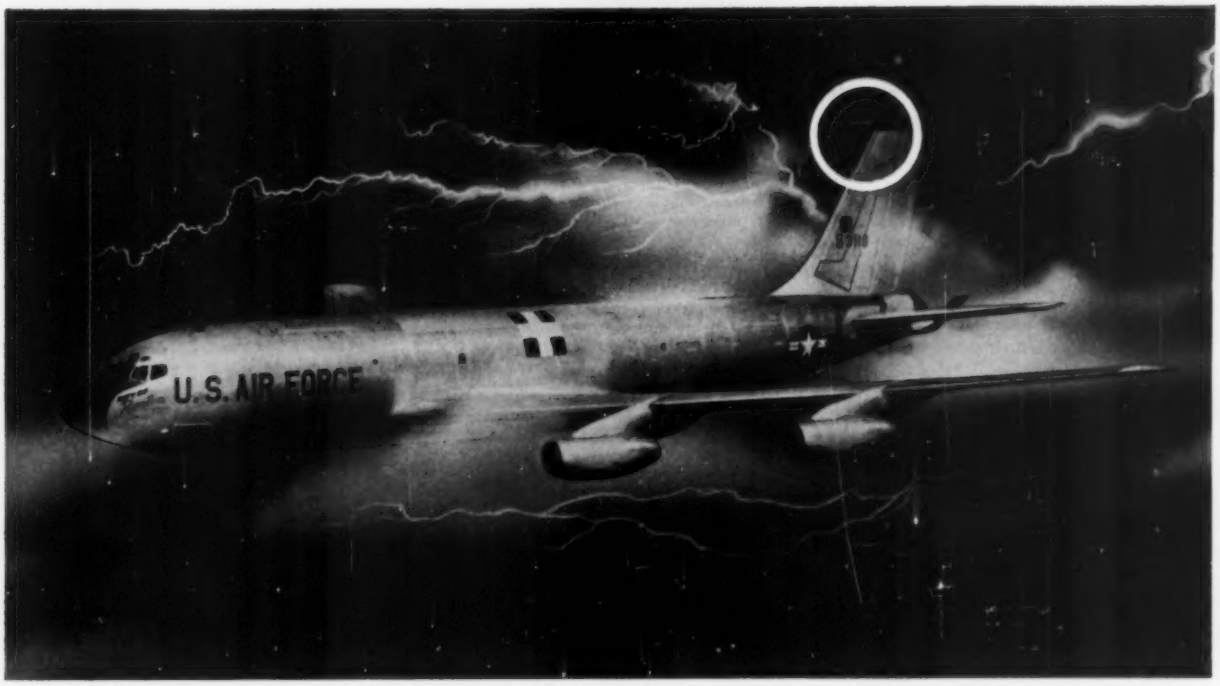
Tin And Its Alloys

HEDGES, CUTHBERTSON, et al. St. Martin's Press, 175 Fifth Ave, New York 10. 7½ x 10, 424 pp. $27.50.

Tin, rarely used by itself as a structural metal, is nevertheless widely used in bronzes, solders, bearing alloys and for coatings. This book, a joint effort of five author-experts, takes a practical approach. It omits the tiresome chapters on mining, and

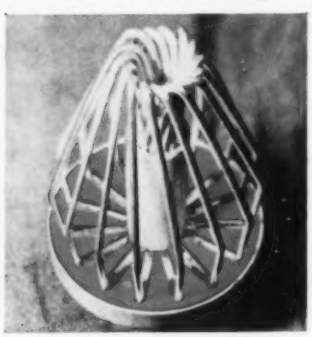
continued on page 108

Where Weight Counts



Use Silicone Glass Laminates For High Strength, Good Electricals

The combination of exceptional properties and ease of fabrication puts silicone-glass laminates in a class alone. Made with Dow Corning silicone resins, these glass cloth laminates are rigid and strong. Just as important, they offer a better strength-to-weight ratio than many light metals. At —80 F or 750 F (even higher temperatures intermittently), silicone laminates retain their high order of resistance to moisture, weathering, ozone, corrosion, thermal shock, vibration and fungus attack. Dielectric properties stay constant.



LIGHTNING BARRIER. An example of how both the mechanical and dielectric properties of silicone laminates can be used to good advantage is illustrated above. A slotted silicone laminate spring guide is a key component of the lightning arrester on this jet aircraft. The arrester protects the probe antennae of long range HF communication systems from damage by electrical discharge. The slotted laminate serves as both a retainer and an insulator for the flexible spring elements.

HEAT REFLECTORS. Ducts, pods, and shields for missiles and aircraft are also made of silicone-glass laminates. In the Super Sabre F-100 built by North American Aviation, a rigid drag chute case is made with these rugged silicone materials. Positioned next to the engine at the rudder base where continuous heat is 750 F, the gold-metallized case resists jet engine ambients, reflects heat away without loss of structural strength.

TYPICAL PHYSICAL PROPERTIES

Flexural Strength, psi	20-40,000
After 200 hrs at 500 F	10-19,500
Tensile Strength, psi	10-14,000
After 200 hrs at 500 F	14-18,000
Tensile Strength to Weight Ratio	4.7×10^{-2}
After 200 hrs at 500 F	9.3×10^{-2}

For further data and a list of fabricators of silicone laminates, write today to Dept. 7214.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

CIRCLE 107 ON READER SERVICE CARD 107

smelting and concentrates on properties and applications. The sections on bearings, coatings and solders are informative and complete, but any such book is difficult to justify at this price.

Thermionic Energy Converter

PB 161713. Dr W L Knecht. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8¼ x 11, 47 pp. $150.

Although it was prepared nearly a year ago, this state-of-the-art review can still serve as an excellent basic text on thermionic converters. Diagrams of the two major types, and performance comparisons with thermoelectric converters add to its usefulness. For anyone interested in advanced energy-conversion systems, it is well worth having.

Other Books of Interest

Galileo Galilei: On Motion and On Mechanics

I E Drabkin, S. Drake. University of Wisconsin Press, 430 Sterling Court, Madison 6, Wis. 6¼ x 9½, 193 pp. $5.

An early treatise on motion and mechanics translated from the Latin and never published by Galileo.

F Gaynor. Littlefield, Adams & Co, 128 Oliver St, Paterson 1, NJ. 5 x 8, 546 pp, paperbound. $2.25.

Brief definitions for terms from physics, mathematics, nucleonics, astronomy, chemistry primarily for the technologically informed layman.

Advanced Euclidean Geometry (Modern Geometry)

R A Johnson. Dover Publications Inc, 180 Varick St, NY 14. 5½ x 8, 319 pp. $1.65.

Unabridged paperback edition of original first published in 1929.

A Treatise on the Differential Geometry of Curves and Surfaces

L P Eisenhart. Dover Publications Inc, 180 Varick St, NY 14. 5½ x 8, 474 pp. $2.75.

Unabridged paperback edition of original first published in 1909.

FBI Register of British Manufacturers—1961

Kelly's Directories Ltd and Iliffe & Sons Ltd, Dorset House, Stamford St, London SE 1, England. 7½ x 9½, 1162. $7.

Bibliography on Electrical Contacts

American Society for Testing Materials, 1916 Race St, Philadelphia 3. 6 x 9, 63 pp. Members $2.80; others $3.50.

Contains references to literature published in 1959.

A Treatise on the Theory of Determinants

Thomas Muir. Dover Publications Inc, 180 Varick St, NY 14. 5½ x 8, 766 pp. $2.95.

Unabridged paperback edition of work originally published in 1933.

Friction and Wear at Elevated Temperatures

PB 161719. E Rabinowicz. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8¼ x 11, 21 pp. 75¢.

Investigation of the Compressive, Bearing, and Shear Creep-rupture Properties of Aircraft Structural Metals and Joints at Elevated Temperatures

PB 161717. L A Yerkovich. Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8¼ x 11, 100 pp. $2.50.

Structural Behavior of Presurized, Ring-stiffened, Thin-wall Cylinders Subjected to Axial Compression

NASA TN D-506. J P Peterson, M B Dow. National Aeronautics and Space Administration, Washington, DC. 7¾ x 10¼, 24 pp. 75¢.

ABSTRACTS FROM THE LITERATURE

"Swiss Cheese" Circuits

Results of miniaturization work on semiconductors are the dot diode and the comma transistor. In the course of development work, potential users asked how these devices could be used. Efforts to answer this question resulted in the "swiss cheese" concept. This involves inserting the

WHY AIR FORCE HAS ADOPTED MICROFILM FOR ENGINEERING DRAWINGS

Recently the Air Force issued new contract requirements of vital importance to companies that are doing—or intend to do—business with its various activities. In essence, the Air Force has made the use of microfilm mandatory for most engineering data and records relating to items delivered by contractors and their vendors.

The new requirements (MCP-71-77) incorporate standards and specifications issued earlier by the Department of Defense for its Engineering Data Micro-Reproduction System. The Air Force move is indicative of the importance of microfilm to the government in saving time, money, and space.

The Air Force is convinced that working with microfilm is easier than working with paper, that it is more efficient and costs less. Filmwork, in other words, is easier and more practical than paperwork for engineering drawings and records.

This is not news to the many industries that use microfilm today. They know that microfilm is a highly efficient and effective production communication tool. They know that microfilm can do many jobs much faster and much more accurately, with almost fantastic savings in time and money.

3M makes microfilm easy to use

"dots" and "commas" into holes in 0.030-in.-thick circuit boards, along with compatible passive devices. Devices are then interconnected either by ultrasonic welding or by stencil printing of conductive adhesives. If desired, this stencil could deposit the circuitry patterns at the same time.

The swiss cheese concept features: Simplicity of interconnection, repairability down to single-device level, high inherent resistance to shake, rattle and roll.

"Swiss Cheese Concept of Circuit Packaging," R. G. Bender, Hughes Aircraft Co, Semiconductor Division, Newport Beach, Cal. Paper No 1.2 published in NEREM Record, Nov '60, Institute of Radio Engineers (Boston section), Boston.

Gas in Aluminum

A study was made of the influence of gas content, pressure and magnesium content on the mechanical properties of aluminum diecastings (type A1-8 Si). The factorial designed experiments were conducted at two levels with die-cast standard test bars. The mechanical properties (yield strength, tensile strength, elongation, impact strength) were affected by pressure and magnesium content, but were more or less insensitive to dissolved gas (hydrogen). Some foundry experiments with normal gassed and degassed metal as starting material for diecastings, and tests on corresponding diecastings complete the study.

"Studies on the Influence of Gas Content, Pressure and Magnesium Content on the Mechanical Properties of Aluminum Diecastings," Dr Werner Ruegg, Head, Chem & Metallurg Labs and Research Dept Injecta Ltd. Paper No 6 published in SDCE, Nov '60, Society of Die Casting Engineers Inc, 19382 James Couzens Highway, Detroit 35.

Metal Cutting

Investigation of discontinuous segmented chip formation leads into a discussion of the shear process. The author discusses the application of his conclusions about the shear process to high-speed machining.

"Shear in Metal Cutting," by F. L. Bagley, Jr, Watertown Arsenal. American Society of Mechanical Engineers paper 60-WA-80, 29 W 39th St, New York 18.

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Information may be imparted by the spoken or written word, which are among man's most ancient means of communications. During the last century the effectiveness of communication has been substantially improved by aural and visual technique requiring a high degree of sophistication and elaboration. However, the over-all communication system is composed of two radically different kinds of elements. One of these is the human being having subjective reactions to the energy stimulating his senses. The other element is the inanimate portion of the system with which is associated the conversion and transmission of the sense-stimulating energy. The author includes curves and other data on responses that subjects gave to aural and visual signals of varying strengths and values.

"Human Responses—A Vital Link in Communications Progress," B. Dudley, Advanced Development Div, Laboratory for Electronics, Boston, Mass. Paper No 24.1 published in NEREM Record, Nov '60, Institute of Radio Engineers (Boston section), Boston.

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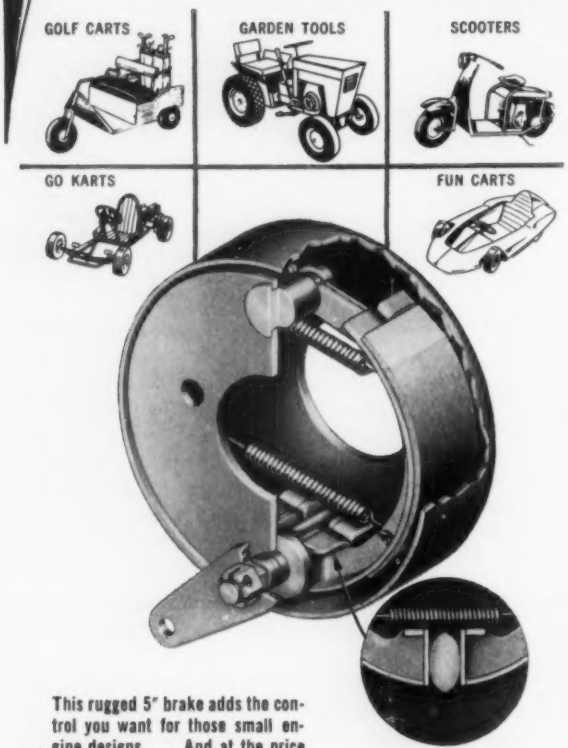

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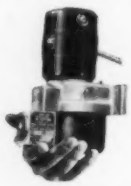

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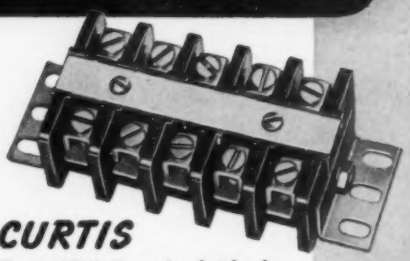

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"How Can We Gain By Improving Our Writing and Speaking Ability?" R. Kendall, Raytheon Co, Waltham, Mass. Paper No 24.4 published in NEREM Record, Nov '60, Institute of Radio Engineers, (Boston section), Boston.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 119.

BALL-BEARING POWER TRANSMISSIONS—Catalog 480, 60 pp. Contains specifications, calculations of bearing loads, dimensional drawings and photographs of wide inner-ring ball bearings with self-locking collars and such power transmission units as pillow blocks, flange and cylindrical cartridges and takeup units. Fafnir Bearing Co, 37 Booth St, New Britain, Conn.

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LOCKNUTS—Condensed catalog, 16 pp. Discusses fastener design; gaging; bolt tightness and wrench torque and offers curves depicting bolt stress tension and impact fatigue. Specifications are tabulated for standard sizes, $\frac{1}{4}$ to 3 in.; prevailing torque types, $\frac{1}{4}$ to $1\frac{1}{2}$ in.; specials, $\frac{7}{16}$ to $4\frac{1}{4}$ in.; weld nuts, #10 to $\frac{5}{8}$ in.; 12 pointer sizes, $\frac{1}{4}$ to $\frac{5}{8}$ in.; and 16 types of Air Force-Navy aeronautical nuts. National Machine Products Co, Utica, Mich.

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PRECISION GEARS AND INSTRUMENT CLAMPS—Pocket-size catalog 5A, 132 pp. Tabulates numbers of teeth, dimensions, tolerances and prices of gear, mounting and synchro locking-clamps; and precision I, II and III gears. Also covers gear blanks and hubs. Perfect Gear & Instrument Corp, 339 S Isis, Inglewood, Calif.

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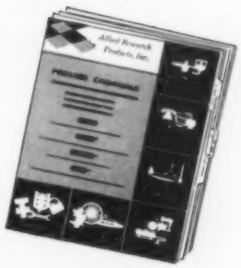

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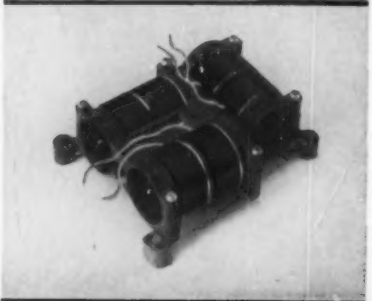

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duction and automatic control. Electronics Div, Cramer Controls Corp, Centerbrook, Conn.

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PRECISION POTENTIOMETERS – Catalog 1160, 28 pp. Details specifications and contains outline drawings of wide range of miniature and full-size units from ½ to 5-in. dia. Electronic Sales Div, DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.

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CIRCUIT-BREAKER LOAD CENTERS –Catalog C-200, 20 pp. Contains wiring diagrams, dimensions and selection tables for: single phase, main lug, split bus and main breaker panels; three-phase main-lug panels; and meter-socket load centers. Bryant Electric Co, Box D, Barnum Station, Bridgeport 2, Conn.

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UNIVERSAL JOINTS AND PROPELLER SHAFTS – Bulletin 502A, 8 pp. Highlights extra close-coupled joint assemblies with torque, moment of inertia and weight data and dimensional drawings. Includes linear dimensions of close-coupled assemblies and propeller shafts. Twin Disc Clutch Co, Hydraulic Div, Rockford, Ill.

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MOTORS AND RELAYS–Bulletin F-9765, 4 pp. Illustrates and outlines specifications of ac shaded-pole unidirectional, reversible and synchronous motors; ac geared and 400-cycle motors; ac and dc tachometer generators; permanent mag-

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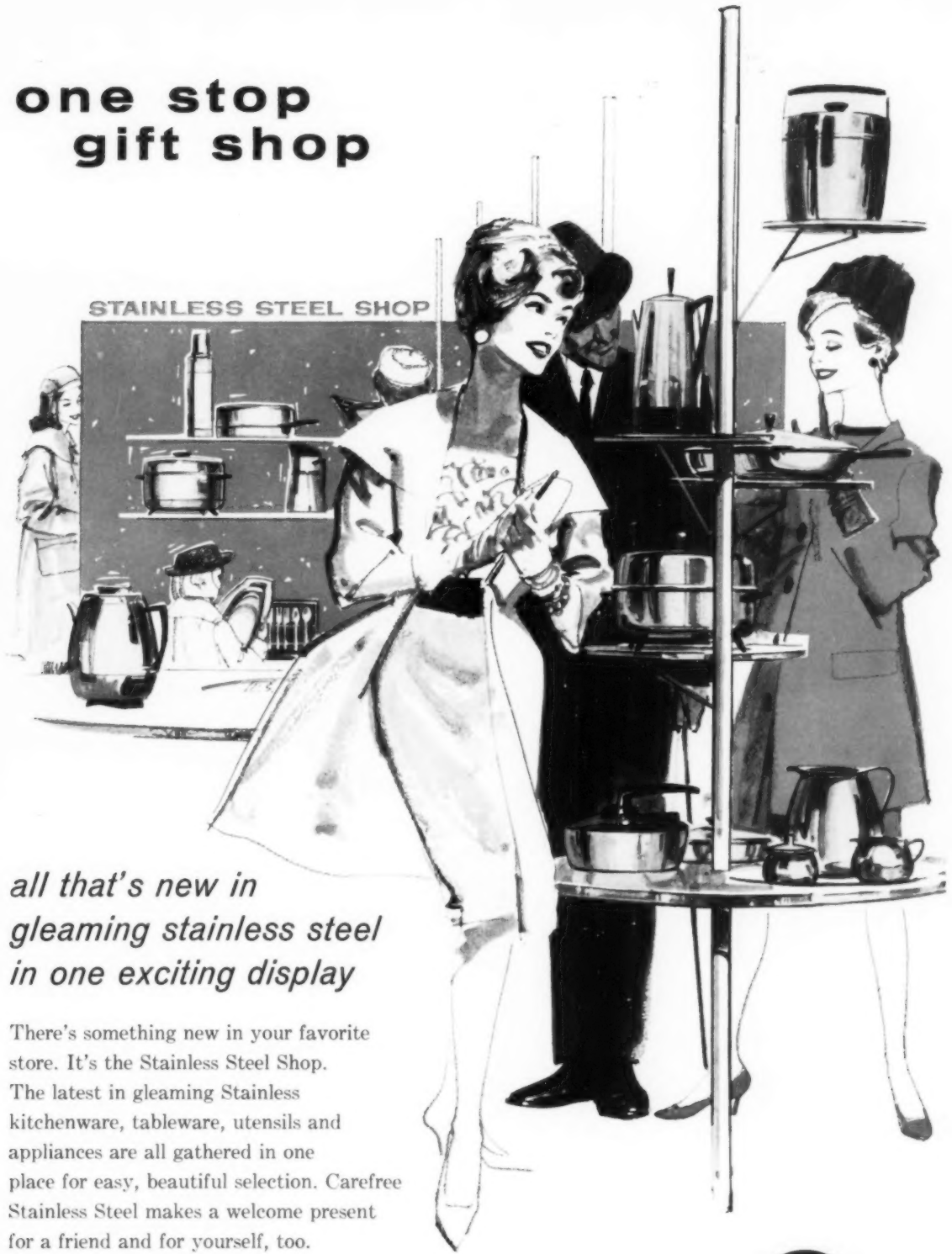

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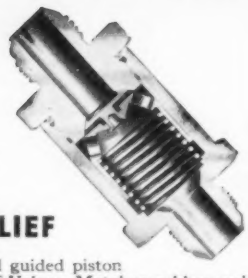

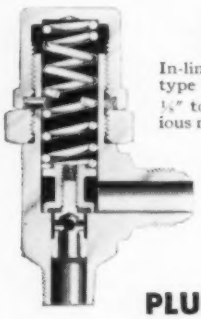

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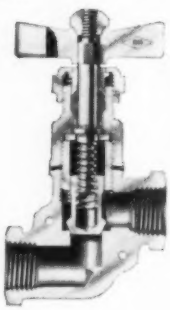

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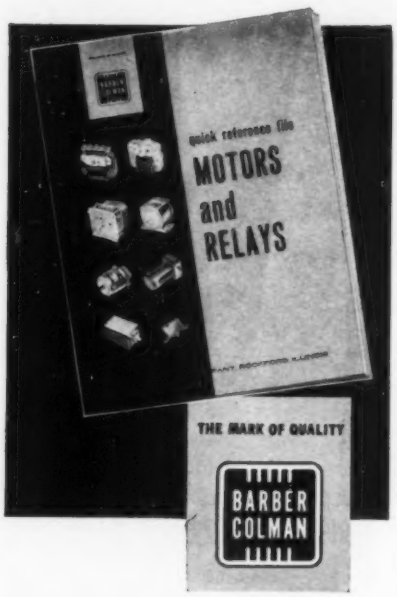

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ROTARY JOINTS—Catalog 310B, 4 pp. Covers working pressure ratings and dimensions of basic design for either single or syphon flow. Cutaway and outline drawings are included, as well as illustrated installation suggestions. Barco Mfg. Co, Dept RJ-26, 500 Hough St, Barrington, Ill.
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TIMING MOTORS AND CONTROLS—Condensed catalog, G-1328, 8 pp. Covers dimensions and design characteristics of electric timing motors, time controls and indicators, electric brakes and

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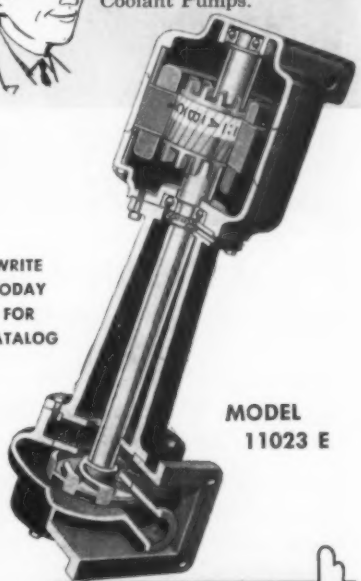

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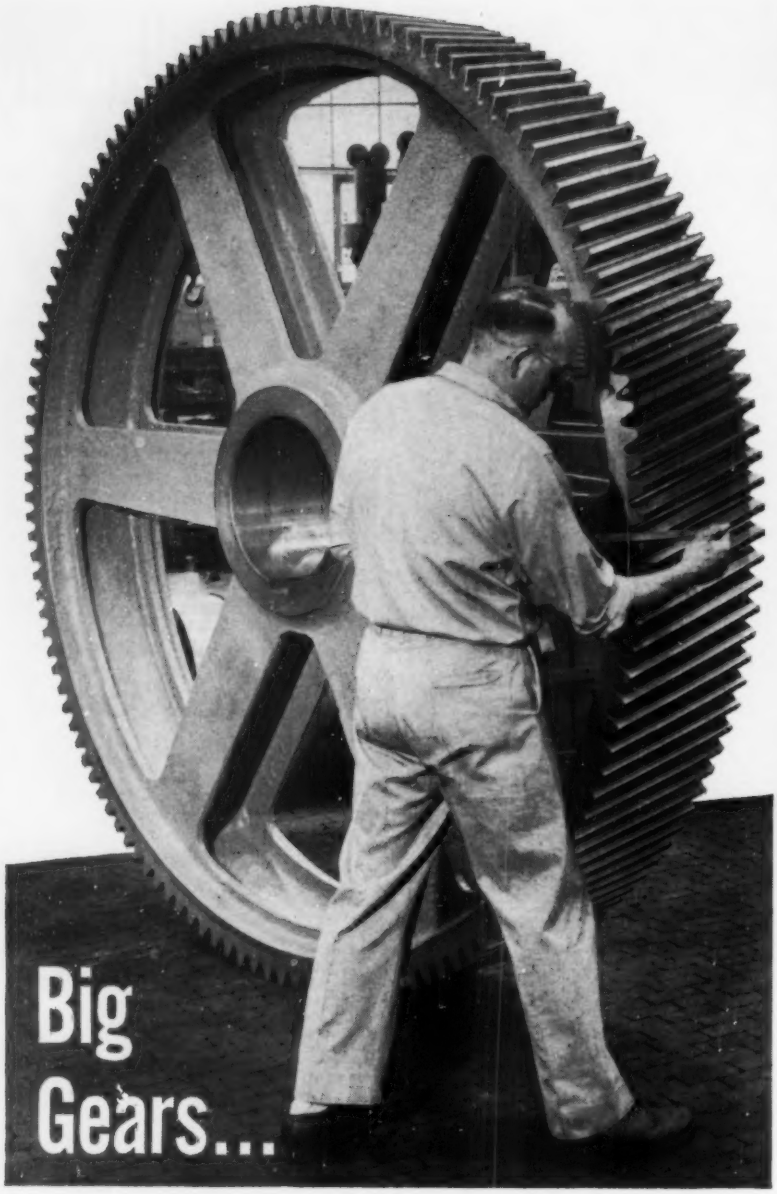

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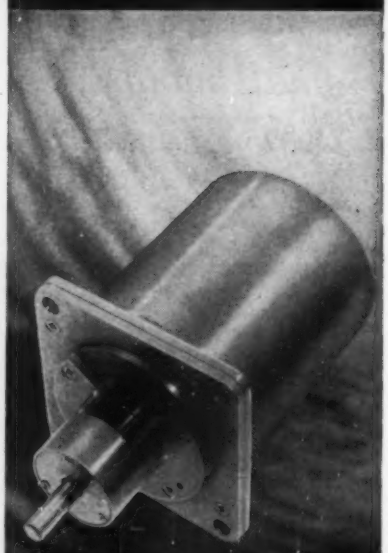

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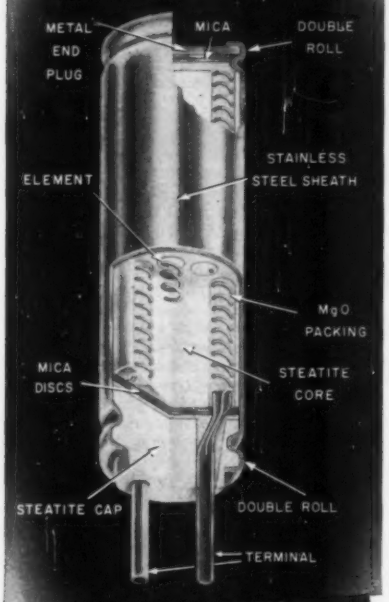

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ALLOY STEELS—Specification chart, 8½ x 11 in. Shows chemical-analysis requirements for many military, Army-Navy aeronautical, and federal alloy-steel specifications. Also lists specified forms—sheets, bars, tubing, etc.—and nearest corresponding SAE, AISI and AMS numbers. Peter A Frasse & Co Inc, 17 Grand St, New York 13.

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VALVE SIZING—Bulletin JSC-1, 4 pp. Outlines information needed for sizing sliding gate regulators and control valves and tells how to adjust sizing for variations in pressure, temperature, viscosity or specific gravity. Tables have recommended valve capacities for saturated steam, water and other liquids, and air and other gases. OPW-Jordan Corp, 6013 Wiehe Rd, Cincinnati 13.

Circle 364 on Reader Service Card

MILL PRODUCTS—Brochure, 16 pp. Illustrates and lists complete line of aluminum, brass, bronze, copper, nickel, silver, rhenium, stainless steel and zirconium mill products and specialties. Chase Brass & Copper Co, Waterbury 20, Conn.

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SWITCHING TRANSISTORS — Brochure, 12 pp. Discusses selection of proper transistors for such applications as saturated DCTL, SCTL, RTL, RCTL and DTL low-level logic circuits, as well as such nonsaturated logic as medium-level switching up to 400 ma and high-level switching, including dc to dc converters and static relays. Schematics, curves and charts show use of inverters and flip-flops

continued on page 119

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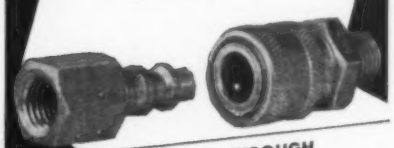

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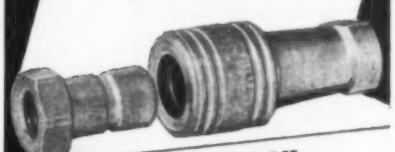

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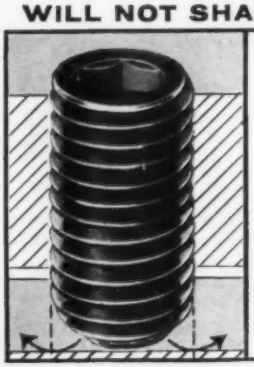

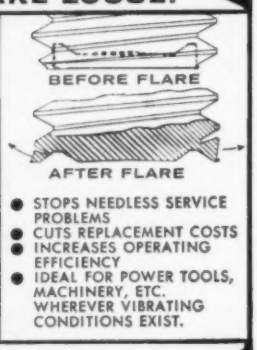

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ROTARY SOLENOIDS—Leaflet 5, 2 pp. Graphically illustrates use of solenoids to drive rotary switches, operate shutters or vanes, or actuate remote counters. Ledex Inc, 123 Webster St, Dayton 2, Ohio.
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INDUSTRIAL BRAKES—Bulletins CE-410, CE-420, 4 and 2 pp. Former describes and illustrates series of dc magnetic brakes, tabulating ratings and clearances. Latter covers similar data on series of ac positive-acting solenoid brakes. Ederer Engineering Co, 2931 First Ave S, Seattle 4, Wash.
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OSCILLOSCOPES—Catalog, 16 pp. Illustrates and gives specifications and prices of over 65 oscilloscopes and associated electronic equipment. Tektronix Inc, PO Box 500, Beaverton, Ore.
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ELECTRONIC COMPONENTS—Catalog, approx 30 pp. Covers specifications and applications for phono input and stub jacks; interlock, phono and speaker plugs; turret terminal and terminal boards; terminal strips and shaft couplers. Assemblies are pictured, along with drawings showing dimensions for chassis cutouts. Accurate Electronics Corp, 169 S Abbe Rd, Elyria, Ohio.
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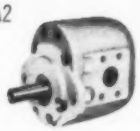

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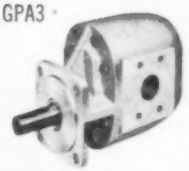

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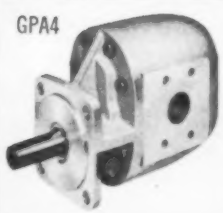

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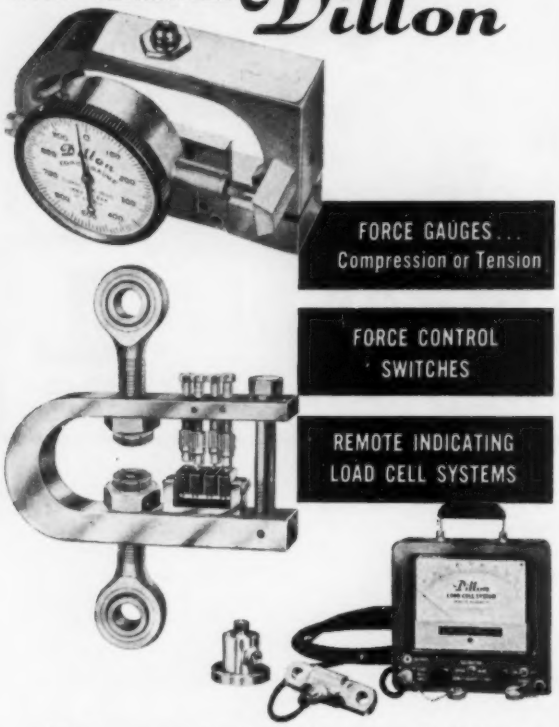

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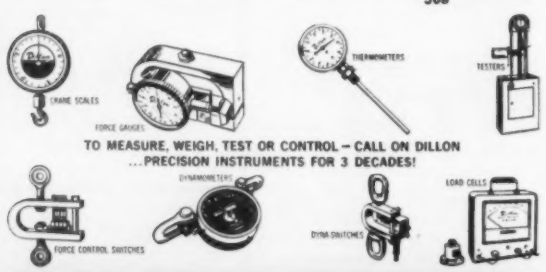

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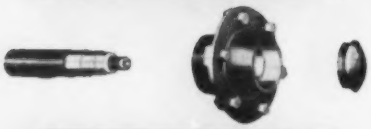

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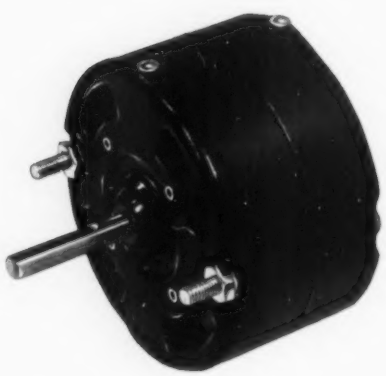

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